Canada. Parliament Senate. Special
Committee on Science policy
Proceedings

1968-69 No 1-9

First Session—Twenty-eighth Parliament

1968 - 69

THE SENATE OF CANADA

PROCEEDINGS

OF THE

SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*

The Honourable DONALD CAMERON, *Vice-Chairman*

No. 1 - 9

WEDNESDAY, OCTOBER 9th, 1968

WITNESS:

Maxwell Weir Mackenzie, Chairman, Royal Commission on Security; Member of the Economic Council of Canada.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29005—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird
Belisle
Bourget
Cameron
Desruisseaux
Grosart
Hays
Kinnear
Lamontagne
Lang
Leonard
MacKenzie
O'Leary (*Carleton*)
Phillips (*Prince*)
Robichaud
Sullivan
Thompson
Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

29005—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

CURRICULUM VITAE

MEMBERS OF THE COMMITTEE

Aird, Hon. John Black B.A., Q.C., (*Toronto*). B. May 5, 1923 at Toronto S. of Hugh Reston Aird and May Black both Can. Ed. Upper Can. Coll., Univ. of Toronto and Osgoode Hall. M. July 27, 1944 to Jane, Dau. of Harry B. Housser of Toronto. Four children: Lucille E., Jane V., Hugh H. and Katherine B. A. Lawyer. Served as Lieut. R.C.N.V.R. 1942-45. Partner; Edison, Aird & Berlis; Vice-President and Director The Algoma Central Railway; Director, Bank of Nova Scotia; Canada Permanent Trust Company; The National Life Insurance Company of Canada; Consolidated-Bathurst Limited; American Metal Climax, Inc. Summoned to Senate November 9, 1964. Party pol.: Lib. Rel.: Anglican. Address: 2 Glenallan Road, Toronto 12; Business: Suite 914, 111 Richmond Street West, Toronto, Ont.

Belisle, Hon. Rheal (*Sudbury*), B. July 3, 1919 at Blezard Valley. Son of J. B. Belisle and Philomene Nault (French Canadian). Married Aug. 21, 1941 Edna Rainville—8 children. Educated at Blezard Valley, Chelmsford and University of Toronto. Councillor, Township of Rayside, 1945; Reeve Township of Rayside, 7 years 1946-52 inc.; Clerk Treasurer of Rayside Township 2 years; President and Director of Sudbury and District Municipal Association; Director of Sudbury and District Home for the Aged; Director of Sudbury and District Chamber of Commerce, 1950-55; Director, Chelmsford & Valley Chamber of Commerce, 1952. During World War II served with the Canadian Army, 1941-43. Entered the Legislative Assembly of Ontario in the new riding of Nickel Belt at the General Election, June 9, 1955. Re-elected at the General Election, June 11, 1959. Secretary of Nipissing and Sudbury P.C.'s, Vice-President of Sudbury and President Nickel Belt. Godfather of five universities. Summoned to Senate, February 4, 1963. Represented the Canadian Senate to NATO Conference in Paris, October-November 1963. Visited NATO military installations in NATO countries. President of Sudbury Insurance Agency. Director of Belden Corporation Limited. Director of Fielding Lumber Co. Ltd. Chairman of the Board of Governors of University of Sudbury. On December 1, 1964 was delegated to represent the Senate at the 19th Session of the General Assembly of the United Nations, New York. April 24, 1965 named for Life, Honorary President of L'Association D'Education d'Ontario. October 4, 1965 represented the Canadian Senate to the 20th Session of the General Assembly of the United Nations, New York, when Pope Paul visited the United Nations. Party Pol. P.C. Rel.: Catholic. Address 403 Simpson Road, Ottawa.

Bourget, Hon. Maurice, P.C., B.Sc.A., M.E.I.C., Ing.P., (The Laurentides). B. Oct. 20, 1907 at Lauzon, Que. Ed. Commercial Academy, Quebec, Lauzon Coll., and at "Ecole Polytechnique" of Montreal. A consulting engineer. Mem. Bd. Dir. of British Nfld. Corp. Ltd. and Hall Corp. of Can. Member Engineering Institute of Canada; Professional Engineers' Corporation of Quebec. Elect. to

H. of C. at g.e., 1940 and re-elect. at g.e., 1945, 1949, 1953, 1957 and 1958. Parliamentary Asst., to the Min. of Public Works, Oct. 14, 1953 to 1957. Can. Del. to U.N., Paris, 1951. Can. Del. Gen. Conf. of Commonwealth Interparliamentary Conference, London, 1961. Joint Chairman of Can. Deleg. to 7th Mtg. Can.-U.S. Int. Group, Washington, D.C. Jan. 14-19, 1964. Summoned to Senate Apr. 27, 1963. Speaker, Apr. 27, 1963 to Jan. 6, 1965. Sworn of the Privy Council, Feb. 22, 1966. Party pol.: Lib. Rel.: Catholic. Address: 59 St. Etienne St., Lévis, Que.

Cameron, Hon. Donald, B.Sc. M.Sc. LL.D. (*Banff*). B. Mar 6th, 1903, at Davenport, England. S. of Donald Cameron and Marion MacFayden, both Scottish. Came to Canada, 1906. Ed. at Lakeview High School and Univ. of Alberta. Degrees: B.Sc. 1930, M.Sc. 1934, LL.D. (Honoris Causa) Univ. of B.C. 1959. M July 6th, 1932, to Stella Mary, dau. of Mr. and Mrs. Samuel Joseph Ewing, of Calgary, Alberta. One daughter: Mary Jean. Professor. Director Dept. of Extension, Univ. of Alberta, 1936-1956; Dir. Banff School of Fine Arts, 1936 to present; Dir. Banff School of Advanced Management, since 1952; Dir. National Film Society of Canada, 1936-1950; Pres. Can. Handicrafts Guild, 1946-49; Mem. National Film Board of Canada, 1943-1950; Chairman Can. Legion Education Services Pacific Command, 1939-46; Mem. National Advisory Comm. on Citizenship, 1939-45; Mem. Can. Institute of Agric.; Amer. Acad. Pol. Science; Mem. Council Can. Assn. for Adult Education; Educational Consultant Performing Arts Magazine. Western Can. Consultant Encyclopedia Britannica; Mem. Can. Govt. Delegation to Ninth Gen. Conf. UNESCO, New Delhi, 1956; Leader Can. Del. UNESCO Conf. Montreal, 1960. Appointed Chairman Royal Commission on Education, Alberta, 1958. Leader Can. Del. Ninth Conf. Commonwealth Parl. Assn. Kuala Lumpur 1963. Dir. Rocky Mt. Life Insurance Co. Summoned to Senate, July 28, 1955. Party pol.: Ind. Liberal. Rel.: United Church. Address: Edmonton, Alberta.

Desruisseaux, Hon. Paul Q.C., L.L.D., (*Wellington*). Lawyer, Editor, Publisher, Broadcaster. B. Sherbrooke, Quebec, Canada, May 1, 1905; S. of Geoffroy François and Sarah (Gauthier) Desruisseaux, grad. St. Charles College, 1928, Montreal College 1931, grad. Law University of Montreal, 1931-34. Post graduate of Batson Institute 1935, Harvard 1935-1936, M. June 16, 1945 to Celine Duchesnes; Children—Louis (deceased), François, Hélèna, Pierre; Admitted to P. of Que. Bar 1934; Practiced in Sherbrooke, Que; Chairman: Radio and Television Sherbrooke Inc., 1967; Quebec Telemedia Ltd., 1967; Melchers Distilleries Ltd., 1967; Honorary Board of Governors of the P. of Q. Association for the Mentally Retarded—1964; Chairman & President: Desmont Research and Development Inc., 1965; Les Publications Sept Jours Inc., 1966; Barwick Printers 1967; President: Cablevision (Montreal) Ltd., 1965; La Tribune Inc., 1955-1967; CHLT-TV, CHLT, CHLT-FM 1955-67; Trilitho Inc., 1964-1967; Cinéma Plaza Inc., 1965; St. Régis Investments Inc., since 1948; Association Canadienne des Quotidiens de langue française 1961-62; Vice-President: Delta Service Inc., since 1961; Cinéma Télécinéma Inc., since 1954; Cinéma Premier Inc., since 1953; Telegram Printing & Publishing Co., Ltd., since 1951; Director: Royal Bank of Canada since 1962; General Trust of Canada since 1961; Shawinigan Water & Power Co., 1961 until its nationalization in 1965; Southern Canada Power Co., 1958 until nationalization in 1965; Director. Shawinigan Industries 1962 until nationalization in 1965; Denault Ltd.,

1961; Quebec Health Services 1961-65; Laurentian Gas Co., since 1960; Financial Expansion Corp. 1959-65; Quebec General Investments Corp. 1962-63; Walter M. Lowney Co. Ltd. since 1962; Forano Ltd. 1962-65; Société d'Expansion Financière 1962-64; Corgemine Ltd. 1965-67; Director: L'Association Canadienne des Quotidiens de langue Française 1959-62; Canadian Press 1963 to 1967; Canadian Daily Newspaper Association 1963 to 1967; Cartier Gas Co. 1963; Westmount Life Assn. Co. 1964; The Canadian General Electric Co. 1964; Montreal Alouettes Football Club Inc. 1964; Terrebonne Development Co. 1965; University of Sherbrooke Corporation 1959; Commonwealth Press Union 1960-67; Sherbrooke Chamber of Commerce; Vice-President: Board of Trusts University of Sherbrooke 1957; Board of Regents of University of Ottawa 1960-65; Governor, Province of Quebec Chamber of Commerce 1964; Governor, Sherbrooke Hospital 1960; University of Sherbrooke 1956; Vice Dean: Faculty of Business Administration University of Sherbrooke, from 1958 to 1964; President: Sherbrooke Section of the Red Cross 1954 to 1957; Ass-Commissioner—Catholic Boy Scouts (Sherbrooke) 1937-39; King's Counsel 1948—Queen's Counsel 1953; Doctor in Law—Honoris Causa, University of Sherbrooke 1964; Commander of the Order of St. Grégoire le Grand 1958; Recipient of the Latin Union, Bene Merenti and French Alliance medals; Member: Club Social, Sherbrooke; Hillcrest; Sherbrooke Country Club; Canadian Club; Quebec Garrison Club; St. James' Club, Montreal; St. George Sherbrooke; St. Denis, Montreal; Forest and Stream Club, Sorel; Summoned to Senate July 8, 1966. Party pol: Lib. Rel: Catholic. Address: 405 Victoria St., Sherbrooke, Que. and 1115 Sherbrooke St. W., Montreal, Que.

Grosart, Hon. Allister, H. G. (*Pickering*). B. Dec. 13, 1906 at Dublin, Ireland. S. of Herbert Montgomery and Elizabeth Mackey, both Irish. Ed. at China Island Mission Schools, Chefoo, North China, 1915-1923; Univ. of Toronto, 1923-1927 Politics and Law and 1928 post graduate International Law. Degrees: B.A., Carnegie Fellow of International Law, 1928. M. July 6, 1944 to Louise Geraldene dau. of Frank George Harnden of Hilton, Ont. Two children: Geraldene Francis and Victoria Elizabeth. Served with Irish Regiment of Can. 2nd Bttn. C.A. (R) with rank of Lt. to Major. Former vice-pres. McKim Advertising Ltd. Toronto and Montreal; former managing dir. Peer International (Canada) and former National Dir. P.C. Assn. of Can. Mem. of Albany (Toronto), Bonaventure (Montreal), Rideau (Ottawa), Royal Can. Geographic Society, Can. Bibliographical Society, Can. Library Assn. and National Press Club (Ottawa). Summoned to Senate Sept. 24, 1962. Party pol. Progressive Conservative. Rel. Anglican Church of Can. Address: The Senate, Ottawa, Ont.

Hays, Hon. Harry William, (Calgary). B. Dec. 25, 1909 at Carstairs, Alta. S. of Dr. Thomas E. Hays and Ambriss Foster. Ed. at Public School, Glenmore and St. Mary's H.S., Calgary. M. Feb. 28, 1934 to Muriel Alica dau. of Ernest Bigland of Calgary. One son: Daniel Phillip. Mayor Calgary 1959-63. Past pres. Can. Swine Breeders Assn. and Southern Alta. Egg and Poultry Producers. Former mem. Alta. Cattle Breeders Assn. and Sheep Breeders Assn. Mem-Calgary Golf and Country Club, Rotary past Dist. Gov. 1963, and Canadian Club. First elected to H. of C. g.e. 1963. Sworn of the Privy Council and apptd. Min. of Agric. April 22, 1963. Summoned to Senate Feb. 24, 1966. Party pol.: Lib. Rel.: Catholic. Address: 8944 Elbow Dr., Calgary, Alta.

Kinnear, Hon. Mary E. (Welland). B. Apr. 3, 1898 at Wainfleet, Ont. Dau. of Francis Manning, Fr. Can. and Mirelda Ann Carter, Engl. Can. Ed. at Port

Colborne P.S. and Welland H.S. M. Dec. 27, 1924 to Robert Alexander (dec. Sept. 14, 1954) son of Louis Kinnear of Port Colborne. Past pres. Victorian Order of Nurses, mem. of Niagara Peninsula Christmas Seals, Red Cross Blood Donors, Port Colborne General Hospital Women's Auxiliary, Business and Professional Women's Club, Ont. Women's Lib. Assn., Women's Lib. Fed. of Can., Port Colborne Country Club and hon. mem. Port Colborne Club and Gyrette Club. Summoned to the Senate April 6, 1967. Party pol.: Lib. Rel.: Anglican. Address: 41 Lakeshore Rd., Port Colborne, Ont.

Lamontagne, Hon. Maurice, P.C. M.Sc. B. Sept. 7, 1917, at Mont-Joli, Que. S. of Alphonse Lamontagne and Sophronie Joncas. Ed. at Rimouski Seminary, Que.; Dominican Coll., Ottawa; Laval Univ. and Harvard Univ. M. in 1943 to iJeannette Morin. Three children: Hélène (Mrs. Lucien Binet), Pierre and Bernard. In 1943, asst. in organizing Faculty of Social Sciences at Laval Univ. and became Prof. of Econs.; Dir. of Dept. of Econs., 1949; apptd. Asst. Deputy Min., Northern Affairs and Nat. Resources, 1954. Econ. Adviser to Privy Council, 1955; resigned in 1957 to become Prof. of Econs. at Ottawa Univ. Apptd. Econ. Adviser to Hon. Lester B. Pearson, then Leader of the Opposition, 1958. Asst. Dean of Faculty of Social Sciences at Ottawa Univ., 1961. Fellow of Royal Society of Can. and Fellow of Royal Society of Arts. First elected to H. of C. g.e. 1963. Sworn of the Privy Council and apptd. Pres. of the Queen's P.C. for Canada 22 April. 1963. Apptd. Secretary of State and Registrar General of Canada February 3, 1964. Professor of Economics at the University of Ottawa since September 1967. Summoned to the Senate April 6, 1967.

Lang, Honourable Daniel Aiken, Q.C. (South York): Barrister and Solicitor, Counsel. Lang, Michener, Cranston, Farquaharson & Wright—Bank of Montreal Building, 50 King Street West, Toronto 1, Ontario; Chairman of the Board, Canada Coal Corporation Limited, President, Standard Trust Company, Member, Board of Governors, University of Toronto, Member, Board of Trustees, Sunnybrook Hospital; Born at Toronto, Ontari, 13 June, 1919, son of Daniel Webster Lang, Q.C., and the late Edna (Aiken) Lang; Educated Upper Canada College; Trinity College University of Toronto, Osgoode Hall Law School 1941 (break for military service) 1945-57; Career—Reed law with Lang & Michener; called to the Bar of Ontario, 1947, joined law firm of Lang, Michener & Cranston, Toronto, with same firm to date, summoned to the Senate of Canada, 1964; served in Second World War with the Royal Canadian Naval Volunteer Reserve, 1941-45, discharged with rank of Lieutenant; Liberal, Treasurer Liberal Party in Ontario, 1958-62, Campaign Chairman Ontario, Federal General Elections 1962, 1963, 1965; Councillor, Municipality of Forest Hill, 1957-61; Married Frances Shields, daughter of Dr. H. J. Shields and the late Cecil (Oatman) Shields, 24 September 1948, has two sons, Daniel and two daughters, Nancy, Janet; United Church of Canada, Trustee, Bloor Street United Church Toronto; Knight, Order of St. Lazarus of Jerusalem; Royal Canadian Yacht Club, Toronto Lawyers' (Pres. 1960-61), Badminton and Racquet, Osler Bluff Ski; Residence 43 Hillholm Road, Toronto 7, Ontario.

Leonard, Honourable Thomas D'Arcy, C.B.E., Q.C., B.A., LL.D. (Toronto-Rosedale) Born April 29th, 1895, at Toronto, Ont. Son of Charles Joseph Leonard and Eleanor O'Brien, both Can. Ed. at University of Toronto and Osgoode Hall. Degrees: B.A., LL.D., (Toronto). Knight Comdr. of the Order of St.

Gregory the Great. Practised law with Jones and Leonard, 1919-34, with Leonard and Leonard, 1934-42. Created Q.C., 1936. General Manager The Canada Permanent Trust Company, 1942-1956. President The Canada Permanent Trust Co., 1951-58; The Continental Life Insurance Company 1955-59; Triarch Corporation Ltd.; The Community Chest of Toronto, 1948; Last Post Fund for Ontario, 1954-58; Canadian Club of Toronto, 1937-38. Vice-Pres. Canada Permanent Mortgage Corporation. Chairman, National War Finance Committee for Ontario, 1943-46. Treasurer Canadian Bar Association, 1948-49. Lieut. 5th Batallion C.E.F. and Royal Air Force. Summoned to Senate, July 28, 1955. Party pol.: Liberal. Rel.: Catholic. Address: 10 Meredith Crescent, Toronto 5, Ont.

MacKenzie, Hon. Norman Archibald MacRae, C.M.G., M.M. and Bar, Q.C., B.A., LL.B., LL.M., LL.D., D.C.L., D. Litt., D.Soc.S., F.R.C.S. (University-Point Grey). B. Jan. 5, 1894 at Pugwash, N.S. S. of the Rev. James Arthur MacKenzie and Elizabeth MacRae both Can. Ed. at Pictou Academy, Dalhousie Univ., Harvard, St. John's Coll., Cambridge and Gray's Inn, London. M. Dec. 19, 1928 to Margaret dau. of A. W. Thomas of Toronto. Three children: Patrick Thomas, Susan Elizabeth (Mrs. Trevor Roote) and Sheila Janet. Pres. Emeritus and Hon. Professor of International Law, Univ. of B.C. Dir. Bank of N.S. Mem. Vancouver Comm. Canada Permanent Trust Co. Hon. Colonel. Served with Can. Infantry 1914-19, 6th C.M.R.'s 85th Bn. N.S. Highlanders. Mem. Univ. Advisory Bd., Dept. of Labour; Advisory Comm. on Univ. Trg. for Veterans, Dept. of Veterans' Affairs; Trustee, Carnegie Foundation for Advancement of Teaching, 1951-63 (Chairman of the Board of Trustees, 1959), Teachers' Ins. and Annuity Assn. of America, 1948-63; Pres. National Conf. of Can. Univ., 1946-48, Can. Club of Toronto, 1939-40—Hon. Sec. 1930-1939; Chairman, Research Comm., Can. Inst. of Int. Affairs, 1929-40; Founding Mem. and Hon. Chairman, National Council, Can. Inst. of Int. Affairs; Del. to Inst. of Pacific Relations Conferences—Shanghai, 1931, Banff, 1933, Yosemite, 1936, Virginia Beach, 1939, Mont Tremblant, 1942, Br. Comm. Conf.—Toronto, 1933, Sydney, Australia, 1938, 7th Congress on Laws of Aviation, Lyons, France, 1925, Congresses and Meetings of Univ. of the Br. Comm.—Oxford, 1947, Bristol and Oxford, 1946, Durham and Cambridge, 1953, Melbourne (observer), 1955, London, 1963, Montreal and Toronto, 1959; Hon. Pres., National Fed. of Can. Univ. Students, 1946-47, 1956-57; Mem. Can. Inst. of Public Affairs, Chairman, 1963, American Society of Int. Law, Canadian Bar Assn., Canadian Political Science Assn., Historical Assn., Vancouver Bd. of Trade, Vancouver Can. Club, Legal Survey Committee (Survey of the Legal Profession of Canada), 1949-57; Fellow, Royal Society for the Encouragement of Arts, Manufactures and Commerce, Royal Canadian Geographical Society; Visiting Lecturer, The Univ. of Australia, 1955; Pres., Can. Assn. for Adult Education, 1957-59 and Visiting Lecturer, International Law, U.N.B., Sept.-Dec., 1963. Chairman, Wartime Information Bd., Can., 1943-45, Reconstruction Comm., N.B., 1941-44; Mem. Royal Comm. on National Development in the Arts, Letters and Sciences, 1949-51; Chairman, Conciliation Bds. in Labour Disputes, 1937-42—1966, Victory Loan Comm., Fredericton and York, N.B., 1941-44, Consultative Comm. on Doukhobor Problems, 1950; Pres., Toronto Branch, League of Nations Society, 1932-36; Vice-pres., National Council of Canadian Y.M.C.A.'s: Dir., Can. Council of Christians and Jews, Western Division; Hon. Pres., Save the Children

Fund, Canada, B.C. Division, Canadian Mental Health Assn.; Hon. Mem., National Bd. of Dir., Can. Mental Health Assn.; Hon. Pres., U.N. Assn. in Canada, Vancouver Branch; Vice-Pres., U.N. Assn. in Canada; Hon. Pres., Student Christian Movement, Univ. of B.C. Branch; Vice-Pres., Can. Authors' Assn., National Branch, 1957; Mem., Can. Council, 1957-63; Pres., Can. National Comm. for UNESCO, 1957-60, 1962-63; Mem., Canadian-American Committee, National Planning Association, 1957-63; Pres., Vancouver Branch, English-Speaking Union of the Commonwealth; Chairman, Canadian Del. to the 10th Annual Conf. on UNESCO, Paris, 1958; Pres., Leon and Thea Koerner Foundation, 1955; Dir., Bank of Nova Scotia, 1960; Mem., Vancouver Advisory Bd. of Canada Permanent Toronto General Trust Company, 1962, East African Comm. on Univ. Education, Sept. and Oct., 1962; Chairman, Mt. Allison Conf. on European Common Market, 1962, Priorities Committee, Community Chest and Council, Vancouver, 1962-64, N.S. Univ. Grants Committee, 1963; Mem., P.E.I. Royal Commission on Financing of Higher Education, 1963-64; Dir., Can. Centennial Commission, 1963; Pres., Can. Centenary Council, 1962; Dir. Fathers of Confederation Memorial Foundation, 1963; Mem., N.B. Industrial Development Board, 1965 and Chairman, C.U.F. Comm. On Int. Studies in Canadian Univ., 1963. Mem. Faculty Club, U.B.C., Vancouver, Vancouver Club and Univ. Club, Vancouver. Summoned to Senate Feb. 24, 1966. Party pol.: Ind. Lib. Rel.: United Church. Address: 4509 W. 4th Ave., Vancouver, B.C.

O'Leary, Hon. M. Grattan. (Carleton). Summoned to Senate September 24, 1962. Party pol.: P.C. Address: Ottawa, Ontario.

Phillips, Hon. Dr. Orville Howard, (Prince). B. April 5, 1924 at O'Leary, P.E.I. S. of J. S. Phillips and Maud MacArthur, both of Can. Ed. at Prince of Wales College and Dalhousie Univ. Doctor of Dental Surgery. M. Aug., 1945 to Marguerite K., dau. of Robert Woodside, of O'Leary, P.E.I. Four children: Brian, Betty, Robert and Patricia. Served R.C.A.F., 1942-45. Mem. Can. Legion, R.C.A.F. Assoc., P.E.I, Curling Assoc, Board of Trade, P.E.I., Dental Assoc. Board of Governors, Prince of Wales University. First elected to H. of C., g.e., 1957. Re-elected at g.e., 1958 and June 1962. Summoned to Senate, Feb. 5, 1963. Party pol.: P.C. Rel.: United Church, Address: Box 155, Alberton, P.E.I. and 195 Grenville St., Summerside, P.E.I.

Robichaud, Hon. Hedard J., B.A., P.C., (Gloucester). B. Nov. 2, 1911, at Shippegan. S. of Jean Georges Robichaud and Amanda Boudreau, both Fr. Acadian. Ed. at Ste. Famille Academy, Sacred Heart Univ., Bathurst, N.B., and St. Joseph's Univ. of St. Joseph, N.B. Dr. of Commerce (Hon.), Univ. N.B. M. Oct. 25, 1937, to Gertrude, dau. of Frederic Leger, of Lower Caraquet, N.B. Nine children: Doris, Mona, Linda, Jean, Robert, Eric, Anne, Louise and Richard. Fisheries Inspector, 1938-1947. Dir. of Fisheries for N.B., 1947-52. Cand. by-election, May 1952 and def. First elected to H. of C. g.e. 1953. Re-elected g.e. 1957, 1958, 1962, 1963 and 1965. Sworn of the Privy Council and apptd. Min. of Fisheries, April 22, 1963. Party pol.: Lib. Rel.: Catholic. Address: Caraquet, N.B. Summoned to Senate, June 28, 1968.

Sullivan, Hon. Joseph Albert, M.D., C.M., (North York). B. Jan. 8, 1902, at Toronto, Ont. S. of Edward Sullivan and Essie Taylor, both British. Ed. at Univ. of Toronto Schools; Univ. of Toronto, M.D., C.M., 1926; Post-graduate work in the University of Toronto, New York and several European Centres.

Physician and surgeon. Honorary Surgeon to Her Majesty the Queen. Member Can. Jr. Hockey Championship Team 1919, Varsity Grads. Hockey Team (Olympic Champions 1928; Consultant in Otolaryngology to the R.C.A.F., 1942, Chief of Dept. of Otolaryngology, St. Michael's Hospital, Toronto, Ont., ,1945; Defence Research Board, Ottawa, 1946; Chief of the Hard of Hearing Clinic & Auditory Research, St. Michael's Hospital, Toronto, Ont., 1950; Mem. of Board of Governors, Univ. of Toronto, 1950; Chief Consultant to the Armed Forces of Canada (Otolaryngology), 1954; Mem. Ont. Cancer Research Foundation, 1954. Mem. of the following Societies: Can. Medical Assoc.; Ont. Medical Assoc.; Academy of Medicine, Toronto; Fellow of Royal Society of Medicine, England; European Collegium; American Otological Society; American Academy of Otolaryngology and Pres. of the American Otosclerosis Study Group. Fellow of the Royal College of Surgeons, Canada; Honorary Fellow of the Canadian Otolaryngological Society; 1963: President, American Otological Society; Honorary Fellow, Otological Section, Royal Society of Medicine. Elected to Honorary Fellowship of Royal Society of Medicine, England, July, 1964. 1968: Elected Senior Member of the Canadian Medical Association. Knight of the Holy Sepulchre, Knight Commander of St. Gregory with Distinction. Clubs: York Club, Granite Club, University Club. Rosedale Golf Club, Seigniory Club, Home Club and Rideau Club. Summoned to Senate, Oct. 12, 1957. Party pol.: P.C. Address: Toronto, Ont.

Thompson, Andrew Ernest Joseph, B.A., M.S.W., (*Dovercourt*). B. December 14, 1924 at Belfast, Ireland. S. of Jospeh Stanley and Edith Magill, both Irish. Ed. at Monkton Combe School, England; Oakwood Collegiate, Toronto; Toronto University; Queens University and University of B.C. Degrees: B.A. (Queens), B.S.W., M.S.W. (U. of B.C.). M. July 26, 1958 to Amy Rusna of Tallinn, Estonia. A social worker. Lt. (R.C.N.-V.R.), 1943-1946. First elected to Ont. Legis. g.e. 1959. Re-elected g.e. 1963. Resigned as Lib. Leader Nov. 16, 1966. Party pol.: Lib. Rel.: Protestant. Address; 1177 Bloor St. W., Toronto, Ont. Summoned to the Senate, April 6, 1967.

Yuzyk, Hon. Paul, B.A., M.A., Ph.D., (*Fort Garry*); B. June 24, 1913 at Pinto, Sask. S. of Martin Yuzyk and Katherine Chaban, both Cdn. of Ukrainian descent. Ed. in Saskatoon, Sask.; Bedford Rd. Coll. Coll. Inst.; Saskatoon Normal School and Univ. of Sask. M. July 12, 1941 to Mary dau. of John and Irene Bahniuk of Hafford, Sask.; Four children: Evangeline Paulette, Victoria Irene, Vera Catherine and Theodore Ronald. Prof. of History and Slavic Studies Univ. of Man. 1951-1963; Public teacher, (1933-39), High School Teacher, (1939-42); Served Can. Army, N.C.O., 1943; Awarded Man. Historical Society Fellowship of $2,500 in 1948. In Man. Historical Society held following positions: Secretary-Treasurer (1953-58), chairman of Ethnic Group Studies since 1952, editor of "Transactions" (1953-57), co-editor of "Manitoba Pageant" since 1956, Vice-President (1958-61), President (1961-63), and secretary of the Manitoba Record Society 1960-64; Associate editor of "Opinion", Winnipeg (1948-49); Editorial Associate of "Ukrainian Directory and Year Book" (1952-56); Founder and first Sect'y-Treas. (1954-56) of the Cdn. Assn. of Slavists; Pres. of Ukrainian Cultural and Educational Centre since 1953; Mem. of General Curriculum Comm., Dept. of Education of Manitoba (1958-59), Y.W.C.A. Advisory Comm. on Adult Education in Winnipeg (1958-63); Author "The Ukrainians in Manitoba: A Social History" (Univ. Toronto Press, 1953); Co-author of

"Ukrainian Reader" (1960), textbook prescribed for High Schools in Manitoba, Sask. and Alta.; Author of "Ukrainian Canadians: Their Place and Role in Canadian Life" (Toronto, 1967); also "Canadiens Ukrainiens: Leur Place et leur rôle dans la vie canadienne" (Winnipeg, 1967); Pres. Can. Assn. Slavists, 1963-64; Vice-Pres. Ukrainian Can. Foundation of Taras Shevchenko since 1964. Mem. Bd. Dir Cdn. Centenary Council. Dir. Can. Council of Christians and Jews (Western Region) since 1963; Social Service Audit, Inc. (Man.) since 1964 and Community Welfare Planning Council (Winnipeg) since 1965. Pres. and Dir. Higher Education Scholarship Foundation (Toronto) since 1966. Mem. Cdn. Del. to 18th Gen. Assem. U.N., 1963. Summoned to Senate Feb. 4, 1963. Party pol.: P.C.; Rel.: Ukrainian Catholic. Address: 1122 Hector Bay E., Winnipeg 9, Manitoba.

DIRECTORS OF RESEARCH

Paquet, Gilles, born in Quebec City in 1936, has done undergraduate work in philosophy and social sciences at Laval University, and graduate work in economics at Laval and Queen's University under fellowships from the Quebec government and the Canada Council. Has lectured in economics at Carleton University since 1963 and is presently an associate professor at Carleton, has conducted research on migration movements, social security, economic development, and urban economies under grants from diverse organizations including the Canadian Council on Urban and Regional Research and the Central Mortgage and Housing Corporation; has published a number of papers on these subjects. Has been associated with the work of the Special Committee of the Senate on Aging, of the Comité de Recherches sur l'Assurance-Santé (Quebec), and is presently a director of La Société Canadienne de Science Economique and the secretary-treasurer of the Canadian Economics Association.

Pocock, Philip John, born in London, Ontario, 19 February 1925. Educated London primary schools; Greygables School Welland, Ontario. Attended the University of Western Ontario; transferred to the Massachusetts Institute of Technology to take a B.Sc. in Aeronautical Engineering. Joined the National Research Council in 1946 and conducted research in the field of fluid mechanics, industrial aerodynamics, the aerodynamic design of aircraft and missiles. On leave from NRC, investigated the design of new aircraft types in the Aero Projects Section of the Royal Aircraft Establishment, England. While at NRC served for some time as Secretary of the Technical Advisory Panel of the National Aeronautical Research Committee and was a Canadian Co-ordinator for the Commonwealth Advisory Aeronautical Research Council. Was appointed Head, Low-Speed Aerodynamics. Laboratory in 1960. Joined EXPO '67 in 1964 where duties included that of Project Officer for the initial planning of the International Exhibition of Industrial Design and Project Officer of the International Exhibition of Photography. Principle extra-curricular activity is concerned with visual communication. In this field he was joint Chairman of an international symposium "Photography and Modern Consciousness" (1967). He is joint author of the book "The Autobiography of J. M. Synge" (O.U.P.).

THURSDAY, September 19th, 1968.

The Special Committee of the Senate on Science Policy makes its first Report as follows:

Your Committee recommends that its quorum be five (5) members.

All which is respectfully submitted.

MAURICE LAMONTAGNE,
Chairman.

MINUTES OF PROCEEDINGS

WEDNESDAY, October 9, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Desruisseaux, Grosart, Kinnear, Lang, Leonard, O'Leary (*Carleton*), Robichaud, Sullivan and Yuzyk—13.

Present but not of the Committee: The Honourable Senator McGrand—1.

In attendance: Philip Pocock, Director of Research (Physical Science).

The following witness was heard:

Maxwell Weir Mackenzie, Chairman, Royal Commission on Security; Member of the Economic Council of Canada.

(*A curriculum vitae of the witness follows these Minutes*)

At 12.10 p.m. the Committee adjourned to the call of the Chairman.

Attest.

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE OF THE WITNESS

Mackenzie, Maxwell Weir, C.M.G., B.Com., C.A. Mr. Mackenzie was born at Victoria, B.C., on June 30, 1907. He was educated at Lakefield Preparatory School in Lakefield, Ont.; Trinity College School, Port Hope, Ont.; and graduated from McGill University, Montreal (B.Com.) in 1928. He joined the firm of McDonald, Currie & Co., Chartered Accountants of Montreal, and in June 1929 he was admitted to the Society of Chartered Accountants of the Province of Quebec. In 1935 he became a partner of the firm. In September 1939, Mr. Mackenzie joined the Foreign Exchange Control Board to assist in establishing wartime control over financial transactions between residents of Canada and residents of other countries, and later he became Chairman of the Board's Management Committee. Mr. Mackenzie transferred to the Wartime Prices and Trade Board in May 1942, and was appointed Deputy Chairman in June 1943. He returned to McDonald, Currie & Co. in May 1944. In the same year he was appointed a member of the Royal Commission on Taxation of Annuities and Family Corporations. In February 1945, Mr. Mackenzie was appointed Deputy Minister of the Department of Trade and Commerce. He appeared on the Honours List, July 1, 1946, receiving the C.M.G. for his wartime services. On August 27, 1946, he was named alternate Canadian delegate to the second part of the First Session of the United Nations General Assembly. He was appointed Deputy Minister of the Department of Defence Production, effective April 1, 1951. On May 1, 1952, Mr. Mackenzie became associated with Celanese Corporation of America, in charge of its Canadian operations, as Executive Vice-President of Canadian Chemical & Cellulose Company, Ltd. He became President of the Company on April 21, 1954. In 1959 he became a Director of Celanese Corporation of America. He was subsequently Chairman of the Board of the two Canadian operating companies associated with Celanese Corporation, Chemcell Limited and Columbia Cellulose Company, Limited. He retired from these activities at Dec. 31, 1967. Mr. Mackenzie is a Director of the Canadian Imperial Bank of Commerce, CANRON Limited, The Imperial Life Assurance Company of Canada, RCA Victor Company, Ltd., and International Milling Company, Inc. He is a Governor of Carleton University and a Director of the Private Planning Association of Canada. In December 1963 Mr. Mackenzie was appointed a member of the Economic Council of Canada. On November 16, 1966, he was appointed Chairman of the Royal Commission on Security. Mr. Mackenzie was married on September 12, 1931, to Jean Roger Fairbairn. They have two daughters and two sons.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, October 9, 1968.

The Special Committee on Science Policy met this day at 10.00 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, this is the first public meeting of the Committee on Science Policy since it was re-constituted by the Senate on September 17. I am pleased indeed to inaugurate this new series of hearings by welcoming Mr. Maxwell Mackenzie, who was prevented from appearing before us last spring by the dissolution of Parliament.

Mr. Mackenzie has had a most successful career both in industry and in the public service. He is a chartered accountant by training. In 1939 he joined the Foreign Exchange Control Board, and in 1942 he moved to the Wartime Prices and Trade Board. In 1944 he went back to his firm, McDonald, Currie and Company, but the following year he returned to Ottawa to serve as Deputy Minister of Trade and Commerce. In that capacity he had a long and close association with the late C.D. Howe.

In 1952 he became associated with Celanese Corporation of America, and in 1954 he became President of Canadian Chemical and Cellulose Company Limited.

In 1963 he was appointed—and I think I had something to do with this—to the Board of the Economic Council of Canada, and he became Chairman of the Council's subcommittee on Industrial Research and Technology.

In 1966 Mr. Mackenzie was appointed Chairman of the Royal Commission on Security.

I take it, honorable senators, that you have not had an opportunity to read the brief that Mr. Mackenzie wants to submit to us; and, if my assumption is correct, I will ask him to go over it and then we will have the usual question period.

Mr. Maxwell Weir Mackenzie (Chairman, Royal Commission on Security; Member of the Economic Council of Canada): Thank you, Mr. Chairman. I was very pleased to receive your invitation to attend this meeting of the committee, and I am delighted to be here today.

I am not sure that I can add much to your deliberations on this very important topic, but I have had some experience with what is called a science-based industry, in the course of which I have come to hold some views that I think may be of interest.

As the chairman has said—I think he has made it abundantly clear, and I want to make it clear—I have no scientific or technical background at all. I am a chartered accountant by profession, and I spent the war years here in Ottawa, and I later became the Deputy Minister of the Department of Trade and Commerce. The Canadian operation of Celanese Corporation, with which I was associated for the last 15 years, comprised a pulp and lumber operation in British Columbia—Columbia Celulose Company Limited—and a chemical and synthetic fiber complex in Edmonton now known as Chemcell Limited. I retired from these activities in 1966, and completely severed my connection at the end of 1967.

I am glad the chairman mentioned the Economic Council, because the subcommittee that I chaired published a report in 1965 entitled: "A General Incentive Programme to Encourage Research and Development in Canadian Industry." I think it would be worthwhile for your staff to review that report, even though the Government did not accept its recommendations. I would like to draw your attention to the composition of the committee. There were four members of the Economic Council, and we brought in six outsiders with considerable experience in the practical management of research. The committee included the presidents of Imperial Oil, Noranda, Domtar, Canada Packers, and Canadian General Electric, as

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well as a past president of the National Research Council, all of these gentlemen acting, of course, as individuals, and not in their corporate capacities.

I have in these notes covered six points that I wanted to make. Whether you discuss them as I go through them one by one, or when I am finished, is completely open. I do not mind a bit. But, I shall start with the first point.

1. The Place of Research in the Innovation Process:

The basic objective of a science policy, and the reason for the Government's interest in it, I assume, is to provide a stimulant to economic growth with all that such growth makes possible for the country. Of itself, research does very little to enhance economic growth. It is only when the results of successful research are actually translated into better products and things, or better ways of producing things, that the real benefits are felt. So, it seems to me that the first fundamental in approaching the subject is to get a perspective of the part that research plays in the whole process of technological innovation or technological development—sometimes called the total innovation process—from which process comes the real contribution to our welfare.

First of all, it can be demonstrated that the countries of the world that show the best economic growth rates, by whatever form of measurement, are the countries that by one means or another direct an important effort into research and development. Japan is, perhaps, an exception, but it seems to me that Japan is so different in so many ways that I do not think it spoils the general argument. That is not to say that all one has to do is to devote effort to research, and something good is bound to come out of it, but a sound research effort seems to be the *sine qua non* to a satisfactory economic growth.

But, it takes much more than just a research effort. A recent study in the United States entitled "Technological Innovation—Its Environment and Management" published by the United States Department of Commerce in 1967, at page 9, gives the following breakdown of the typical costs involved in successful product innovation:

Research and Development ..	5%-10%
Engineering and Design	10%-20%
Tooling, Manufacturing Engineering (getting ready for manufacturing)	40%-60%
Manufacturing Start-up Expense	5%-15%
Marketing Start-up Expense ..	10%-25%

In other words, research and development as such comprises between 5 and 10 per cent of the total cost of bringing in a new product.

The study then goes on to say:

> We need to bear in mind that the path between an invention (or idea) and the market place is a hazardous venture, replete with obstacles and substantial risks. It is ordinarily a very costly, time-consuming and difficult task that the innovator faces...

It seems to me that this must be continuously borne in mind in framing a national scientific and research policy. If the subject is approached from the point of view that successful research is of itself the objective, we are likely to be disappointed in the end results. Presumably we in Canada are not putting hundreds of millions of dollars into our atomic research programmes just for the sake of increasing our basic knowledge. We must plan to develop something from it that will be of use to us in our daily lives, and, indeed, in our ability to trade with the rest of the world. I am not here talking of the original research, or its early development. But once the basic work is done, the further development must be toward some economically viable objective, and the carrying through to that stage is the really expensive part of the process. It is also the part of the process that most importantly calls for the setting of priorities—the balancing of the expected costs against the economic viability of the expected results. I shall come to the need for priorities in the next section of this memorandum, but I would like to add a further comment about the relationship between the early stages of the innovation process.

Let me draw your attention to one aspect of some of the regulations that have been set up in the past concerning assistance for industrial research. It is, of course, necessary to define what is meant by industrial research, and various and differing definitions are found in

the Income Tax Act, the Dominion Bureau of Statistics instructions, and the regulations of the Department of Industry. If those definitions are narrowly drawn and rigidly enforced, as I think from time to time they have been, they fail, in my opinion, to accomplish their real objective. If it were my decision in administering a research assistance programme, I would not be concerned whether a particular item of expense that might be eligible for government support came within the strict definition of the R&D element, or whether it overlapped a bit into the other phases of the innovation process. I make here no detailed assessment of these various definitions; indeed, I am not competent to do so, but simply issue a plea for the adoption of one standard definition and liberalization of its terms and application.

To underline this recommendation may I point out the difference between the R&D contribution to the development of the United States economy and to those of the European countries. It has, I think, been shown pretty conclusively that there is not the great gap in scientific knowledge and in R&D on either side of the Atlantic that is sometimes assumed. The gap comes from what is done with the results of R&D. Time and again we hear of British or European developments of tremendous importance, but more often it is in the United States than in, say, the United Kingdom that these things get translated into actions that make real contributions to economic growth. This committee is, I know, concerned with scientific policy, and not the whole question of economic growth, but my plea is that scientific policy should not take a narrow view of these matters if it is to achieve its real objectives.

2. The Need for Priorities:

The Government took a very important and potentially a very useful step in setting up the Science Council and the Science Secretariat. I assume that their major preoccupation will be the establishing of priorities which, because of our size and limited facilities, must be of the utmost importance. Before the creation of the Science Council there was no practical mechanism for coordinating the scientific effort of government. During my time in Ottawa as Deputy Minister priorities were determined by the forcefulness or otherwise of the individual minister concerned. A forceful minister got his departmental projects through and a less forceful one, who might have had a better project, often failed. It was, I think, particularly fortunate for Canada that Mr. Howe was in office when a start was made on our atomic activities, for he alone carried the ball at first.

The setting of priorities is, of course, tremendously difficult: First in assessing the claims for support from the different disciplines, and then in the judgments that must be made as between the individual contenders for government assistance, namely, governmental, institutional, and industrial organization.

The importance of priorities increases, of course, the farther one gets away from the basic research field toward the applied research field, from the search for new knowledge to the translation of new knowledge into useful things and processes. It is in this latter stage that the managerial judgment is so important if we are to get real value from our research efforts. Questions must be asked as to the economic potential of the project if the research is in fact successful.

I do not want to revive the old controversy about the ill-fated Arrow programme by mentioning it, but it seems to me that it illustrates what I have in mind. There were at the time the project was started real doubts about our ability to sell the aircraft to our NATO allies, no matter how successful the project might be. Without such sales, economic production in Canada was impossible. Some of our allies could not have afforded the purchase and others would have found it very difficult, for reasons of national pride and other considerations, to use a first line fighter aircraft designed and supplied from offshore. These are not questions to be decided alone by the scientific community—but they have a real bearing, or should have, on our decision to spend or not to spend millions of dollars on the research effort involved.

The Science Council has not yet had time to really show what it is capable of doing but I would hope that any pronouncement of scientific policy that this committee may make will stress the need for a continuing body of independent government advisors drawn from those with established expertise in the field, supported by a suitable secretariat.

The ultimate decisions must, of course, be made by the government of the day, but it seems eminently clear that any group of ministers, concerned with the myriad of problems that are theirs, need advice from

some detached body on matters as complicated and technical as scientific policy.

3. The Need for Government Assistance to Industrial Research and Development:

If one accepts the desirability, and indeed the need for a strong R and D effort in the country, the question can be asked: is it necessary for the Government to specifically assist industry's efforts? Will not the returns from successful R and D by industry be a sufficient inducement?

The basic justification to my mind for government support is that the general social gains from R and D far exceed the average gains that are likely to accrue to the individual firm. This issue was very well stated by Harry G. Johnson in *Federal Support for Basic Research: Some Economic Issues in Basic Research and National Goals*, published by the National Academy of Sciences in 1965. He said:

> The market will arrive at a socially efficient allocation of resources provided that the risks undertaken by and the prospective returns open to the private decision-taker coincide with the risks and returns to society as a whole. These conditions are not fulfilled for private investment in research, and particularly for private investment in basic scientific research. The risk to the private investor in the creation of scientific and technological knowledge is greater than the risk to society, because the knowledge that results from the research may be useful to someone else but not useful to him, and the return to the private investor is likely to be less than the return to society as a whole, because the benefits to society cannot be fully appropriated by charging for the use of the knowledge. These divergences of private and social risks and benefits are by definition greater for basic scientific research than for applied scientific research; they are also smaller for the large diversified research organization or industrial corporation than for the small specialized research organization or company.
>
> ... In consequence, there is good theoretical reason for expecting that, left to itself, the market would not only tend to allocate too few resources to research in general, but would also tend to bias the allocation against scientific research as contrasted with applied scientific research.

He was there talking more particularly about basic research as against the more general type of industrial research, but the argument still holds. Another writer on the subject, F. Machlup in *The Production and Distribution of Knowledge in the United States*, put out by the Princeton University Press in 1962 says:

> The discrepancy between social and private benefits of R and D is due, among other things, to two consequences of the introduction of improved technologies: (1) The prices of the products concerned are usually reduced, which will benefit the consumer, not the innovating producer. (2) The new technology is adopted sooner or later by his competitors, which may help them as well as the consumer, but not the innovator. This does not mean that the investor in R and D and first user of the new technology will not benefit from his investment; it merely means that the benefits to society as a whole are not limited to the benefits accruing to the investor, and will often exceed them substantially.

This general reasoning leads me to the conclusion that there is a good case for a general incentive plan to encourage industrial research and development apart altogether from any plans that may be devised to encourage any particular projects that are thought to be in the national interest.

4. The Nature of Industrial Research:

It is hard to think of any field where there is a greater need for the principle of decentralized decision-making than in industrial research and development. Its success rests entirely on individual initiative, from the junior research assistant to the senior research director of the firm. Top company management must, of course, set goals and determine general directions, but within that framework there must be freedom to move around, to innovate and to explore. Under these circumstances it seems to me that any contribution that government can make to stimulate the general industrial R and D effort should be in the nature of improving the general climate rather than any plan based on the assessment of the worthiness of individual projects.

In April 1965, the then Minister of Finance said, in introducing a plan for the general support of industrial R and D:

> Those who wish to receive assistance based on larger expenditures than this—

That was $50,000 a year—

> will be able to do so by getting prior agreement from the Minister of Industry that the research and development proposed, if successful, would be likely to benefit Canada.

I come back later to the nationalistic implications of that statement, but I think it illustrates an approach that is not conducive to successful stimulation of our industrial R and D effort.

First of all, a $50,000 a year limit is pretty small when a young Ph.D. just out of college earns about $12,000 a year these days. But worse than that is the requirement for prior approval of the development proposed. With the best will in the world, and with the most competent federal government officers possible being involved, how can they second guess the men in industry, who have equal if not better scientific training and whose very jobs depend on running a successful R and D effort for their companies?

This is not quite like saying that what is good for General Motors is good for the United States. We are here talking about a very specialized field, assessing the probable success of a proposed research program. I know of no better criterion by which it should be judged by the government than whether or not some taxpayer is prepared to put his own money into the program and to take his government assistance in the form of income tax rebates, that is only if he is successful, not necessarily in that particular project, but in his overall efforts.

In the recommendations made by the committee of the Economic Council, to which I referred earlier we were most specific in urging that government assistance for industrial R and D take the form of tax allowances, with appropriate provisions for carry forward to future years of research costs made in unprofitable years. We disagreed with the plan of grants-in-aid for prior approved projects as a general form of incentive. Obviously there is room for a system of grants for particular projects, but this should be supplemental to the main incentive scheme.

It seems to me that the chance of any company engaging in purely frivolous research is very small indeed. A great deal of research effort, of course, comes to a dead end and can by certain criteria, be regarded as wasted. But that is the way the game is played.

Successful research needs management interest and support. This means that, first, the research projects must be related to the needs of the business; second, in order to recruit and retain the necessary talent the research projects must be scientifically challenging; and, third, support funds must be available on a continuing basis. These objectives can be met most effectively, and at the least overall cost to the taxpayer, by business income tax incentives. Such incentives are open to all and are simple to administer. They can make a significant contribution to the cost of research but still demand a financial commitment by those companies that elect to qualify. In other words, I believe that all general efforts by the Government to stimulate activity in this field should be by improving the climate, rather than addressing the particular projects that may be under way at any given point in time.

5. The International Aspects of Research and the International Companies:

One of the really vital developments of this century, thinking in terms of world trade and the general economic environment, is the growth of what are loosely described as international companies and the part they play in world trade and economic growth. No useful statistics are available that I know of to measure their influence, but one can make a few "guess-estimates". I saw a calculation the other day that impressed me. If one takes the value of United States direct investments abroad, currently estimated at about $55 billion, one can assume that this generates a sales volume of, say, double that amount, or $110 billion. Comparable figures for the rest of the free world might well bring that figure to $200 billion a year. That in turn compares with a Gross National Product for the free world of $1,750 billion. Out of $1,750 billion, $200 billion—while important—is perhaps not so startling a comparison but, if one projects those figures forward for, say, 20 years and assumes a 4 per cent annual growth rate for national GNP's but a 10 per cent growth rate for the international companies—and 4 per cent and 10 per cent respectively are not out of line with recent experience—one gets to the point in 1987 where one-third of the free world's GNP will derive from the international companies. I do not want to hang too much argument on that arithmetic but I do think it illustrates that the international companies are beyond question a force to be reckoned with in any future planning.

Now, these companies are in large measure science-based companies—and their very size

has been dictated, among other reasons, by their need to be able to support extensive research and development efforts. My own experience has proven to me that no purely Canadian company, that was basically operating in the Canadian market, could possibly function effectively in the synthetic fibre field without access to the R and D of some much larger international company. Thus, we find in Canada, Chemcell with which I was associated, as part of the Celanese family. CIL is part of the Imperial Chemical Industries family; Dupont of Canada is in the Dupont family; and Courtaulds of Canada in the Courtaulds of England family. Licensing and royalty arrangements are useful but are no substitute for direct access to continuing technological developments. By definition the licensee is never in the forefront; he is always a few laps behind. I suspect that what is true in the synthetic fibre field is true in many others—and whether we like it or not the big international companies are now a fact of life. They are here to stay and we have to learn to live with them, and hopefully to develop more of our own.

This, it seems to me, has a real bearing or should have a real bearing on our scientific and research policy. It is a companion piece to the almost trite saying that scientific knowledge, like all knowledge, knows no national frontiers. No industrial R and D effort, that was worth its salt, could operate on the basis of solely Canadian scientific knowledge; it must have access to what is going on in other parts of the world. And this brings me to the point of Canadian nationalism in our research policy. I firmly believe that the Canadian Government approach to the encouragement of industrial research should be to develop a competence for good research in Canada rather than the narrow approach of looking at individual projects to see if they themselves "will benefit Canada".

In Chemcell we had access to a tremendous volume of material in the R and D departments of Celanese Corp. That access, however, was worthless unless we had the trained personnel in Canada to know how to use what was available to us. In order to have that competence we had to have our own R and D effort in Canada—and one good enough to attract good people to it—which means among other things an opportunity for the scientific personnel to do original work on their own. In our view, the important matter was not whether the results of their labours in Canada were ultimately followed through in Canada or elsewhere. The absolute amount they could produce in any event would probably be small in comparison to what was available to us through the huge R and D effort of Celanese. What was of primary importance was to have in Canada a competence to take advantage of what was available to us.

Let me cite a case history from my own experience. Celanese Corp. in its laboratories in the United States developed, to bench scale, a process for producing pentaerythritol—a polyhydric alcohol made by combining acetaldehyde and formaldehyde. It is used extensively in the manufacture of many types of surface coatings for such applications as automobile finishes, refrigerators and other domestic appliances, paints for railway box cars and many types of enamels. It is also used in the manufacture of explosives and in some plasticisers.

Chemcell was given the opportunity of bringing this development into actual production. This meant bringing it from the bench scale, through the pilot plant stage and ultimately to the commercial production stage. A very substantial amount of further R and D work was required for this purpose, which we undertook at Edmonton—and eventually we were successful. The plant has been increased to some extent in size but more importantly by improved processes and techniques until it is now one of the largest, if not the largest, units producing this product in the world. We believe it is also one of the most efficient in the world. We got to the point where, apart from the Canadian market which is only a few million pounds a year, we had almost 10 per cent of the whole United States market and sold in some 35 or 40 other countries. Taking Canadian raw materials that sell for less than one cent a pound—and here I refer to butane and propane from which we made acetaldehyde and formaldehyde—and producing a product that sells in export markets for over twenty-five cents a pound, is certainly good for the Canadian economy. Eventually, the demand in the United States was such that Celanese decided to build its own plant in Texas, which they did in large measure on the basis of our R & D effort in Canada. In the result we have, of course, lost most of the United States market for the Canadian company; but we still have a 50,000,000 pound production in Canada that we sell in some 35 or 40 different markets. Here was a situation based in the early stages

on R & D done in the United States—but then very largely on R & D done in Canada. The work done in Canada has undoubtedly benefited Canada, but not exclusively; it has also benefited the United States. But, without access to the original work in the United States first, the development just would not have happened in Canada.

In another field, with which I am connected, RCA Victor Company Ltd. conducts a very substantial research and development effort in Canada—and, by arrangement with its parent, it has specialized in certain areas of research in Canada which complement rather than duplicate the research efforts of RCA in the United States. This means that the experts in these chosen fields are in Canada, and there is therefore a strong reason why the development of a new product should be carried out in Canada—and, indeed, the technical and sales service function performed by Canada. This is what has happened with manufacturing in Canada and world-wide sales made from Canada of these particular products. Presumably, this will continue so long as other Canadian conditions, such as taxation, are not more onerous than in the United States. But, here again, the R & D effort, while centered in Canada, is not exclusively Canadian. There must be a free play between the Canadian scientists and their counterparts in the United States. The Canadian researchers need access to what has been done in related fields in the United States laboratories and, indeed, the United States researchers need similar access to the Canadian effort. While there can be some degree of specialization between the two, they cannot operate in watertight compartments.

Any attempt to "nationalize" the results of the Canadian effort, either by legislation or by regulation, can only act in one direction—to reduce the effectiveness of the Canadian research operations—with a consequent diminution of its contribution to our welfare.

I do not want to suggest for one moment that a research effort in a purely Canadian owned and operated company is necessarily inferior to a research effort tied into an international company. It simply means that the purely Canadian company must find other means of getting such information as it needs from foreign sources, because this it must have.

My point is that, with the tremendous development of international companies and the huge reservoir of technical knowledge that they have, we defeat our own ends if in our research and development policy we discriminate in any way against them as compared to purely Canadian companies.

My views, I am sure, are coloured because my industrial experience has been entirely with the Canadian subsidiary of a large United States company. But this is the area that has caused concern to those in Ottawa who have framed our industrial research incentive plans, and are concerned that the results of research should "benefit Canada".

6. The Concept of Centres of Excellence and the Brain "Drain" or "Gain":

There is only one more small point I want to make, and that is that we hear a good deal these days about the "brain drain" and questions are raised about the wisdom of spending large sums of public money to develop highly trained scientists who, when their education is completed, go immediately to the United States.

Undoubtedly there will be some such movement, but it is not just in one direction. Each year Canada receives quite a substantial number of trained scientists from the United Kingdom, Europe and other countries, and the net "drain" or, possibly, "gain" is a very different matter from the gross figures.

However, this situation simply reflects another aspect of the international nature of the scientific endeavour; and, if we want to deal with it, there is in my mind only one basic approach that we can take.

The good scientists who go to the United States are attracted, I believe, not so much by the somewhat higher incomes they make but by the wider opportunities they think they will have in their chosen field. Probably more than in most other types of employment, the attraction to a good scientific researcher of working with or under recognized leaders in the field is the strongest drawing card; and the country where the work is carried out is secondary. Obviously living and working conditions have to be satisfactory. Columbia Cellulose, for example, was unable to build up a good research organization at Prince Rupert, which we tried to do. Eventually we had to move the whole department to Vancouver because, with such a demand for good men in the pulp and paper field, we could not get first-class recruits to separate themselves from the larger centres, particularly those with appropriate universities and other research establishments in the environs.

I am persuaded, particularly by our experience in Edmonton, that the concept of a centre of excellence is what counts. Located in an area where there is a reasonably sized scientific community, a comparatively small research and development activity can be mounted, provided it has at its head men good enough to attract others and occasionally to bring distinguished scientists to visit, to lecture and, possibly, to participate in its programs. It does not have to be large but, if the quality is there, there is not too much difficulty in recruiting and holding staff.

Again and again one comes back to the same thing: Good research needs an appropriate climate, and I believe that all general efforts by the Government to stimulate activity in this field should be toward improving the climate, rather than addressing the particular projects that may be under way at any given point of time.

May I sum up the six points I have tried to make by saying that:

1. Research is only a small part of the innovation process which is our real objective.

2. There is a most pressing need to develop priorities.

3. Industrial research merits a general incentive plan.

4. By its nature, industrial research is dependent on decentralized decision-making. Tax incentives provide the most effective scheme for encouraging such decentralized decision-making.

5. We should accept and not be afraid of the international implications of research.

6. Concentration on centres of excellence is our best defence against the brain drain.

The Chairman: Thank you very much Mr. Mackenzie. It is time now for a recess; we shall reconvene in ten minutes. (*Short recess*)

(*Upon resuming*)

The Chairman: May we come to order? Senator Grosart.

Senator Grosart: Mr. Mackenzie, this is a most interesting paper you have put before us. I tried to get a copy of the economic report to which you referred, in order to see what your committee did recommend. I am sorry to say that our Parliamentary Library does not seem to have a copy of the Report of the Economic Committee.

Mr. Mackenzie: I can arrange for that.

Senator Grosart: There may be one which somebody else has borrowed. The information I had was that one was not available. In any event, looking over your paper, Mr. Mackenzie, I realize that you are dealing largely with industrial research, which, as you know better than I, is not the whole field of research.

The Chairman: By the way, Senator Grosart, before you go on, I think it would be a good idea if a copy of that report could be circulated to all members of the committee.

Mr. Mackenzie: That can be very easily arranged.

Senator Grosart: Mr. Mackenzie, could you indicate to us to what extent the conclusions you have reached about the method of Government allotment of research funds will apply in the larger, sociological field, for example, to such things as research into air and water pollution?

Mr. Mackenzie: This, it seems to me, is the sort of job the Science Council should address itself to. These areas are particularly suitable for research being done in Government organizations, such as the National Research Council, the Defence Research Board and so on, and in universities by sponsored projects and by other research establishments, as distinct from the fields that should be handled in the industrial sector.

I have the feeling that in a great many of these major areas, such as air pollution and water pollution, some of the basic work has to be done either in Government or, for example, by sponsored projects in universities as distinct from industrial research. On the other hand, there are fields in which the Government has concerned itself that might more appropriately be the concern of industry. I am not competent to really express an opinion, but I believe the National Research Council for some time did quite extensive research into building materials that would be used for housing in the north and so on. There may be some special aspects of that, but a lot of the building material research, it seems to me, could be done just as well in industry as in a Government department.

On the other hand, if you are addressing yourself to such problems as the water pollution in Lake Erie, some of the basic research has to be done by Government sponsored projects as distinct from industry.

Senator Grosart: Your two main suggestions, it seems to me, are, one, the negative one that industrial research should not be subject to prior Government approval, that is, in respect of any Government assistance, and, two, that Government assistance should be in the form of tax rebates or tax incentives. You also discuss the definition of research. I wonder if you would suggest how, without prior approval, it will be possible for a Government to decide what is industrial research in the sense that you use the term. I am thinking of the very large amount of industrial research that has really no direct social values but is merely concerned with product switches. That is, it is not concerned with product innovation but with product switching. Is this not so? A great deal of research money does go into switching the product from "Duz" to "Zam" or "Zim" or whatever. How would you make a distinction? If your industrial firm said that this was research and therefore wanted a tax incentive in respect of it, how would the Government know what was what if it was not subject to some kind of prior checking?

Mr. Mackenzie: Until this new approach came in a few years ago, we did rely on definitions in the Income Tax Act and regulations and in the Dominion Bureau of Statistics —definitions as to what was meant and what was covered and what sort of research would be eligible for these programs which were tax incentive programs. Those definitions were not perfect. They could have been improved. But I do not think it is beyond the scope of a good draftsman to define what the Government means by research. At the moment there is an exclusion of anything in the nature of market research.

Following that, perhaps your soap illustration is market research as distinct from research to improve the product. But if a large soap company were to undertake a project which would make a material contribution to the pollution aspect of synthetic detergents as distinct from soap, that would certainly be worth-while. I have been told that detergents are a major factor in the problem of pollution. If there were some basic research that could change the chemical nature of detergents so that they would not have the present deleterious effect, clearly that would be a type of research that should be covered by an incentive program. However that is a very different matter from the question of market research in which you research to see whether you can persuade a housewife that one product is superior to another.

Senator Grosart: It goes a little further than that, Mr. Mackenzie. It is not just a question of mere market research, because market research very easily becomes product research and product innovation, which is what you are talking about. To take another example, perhaps an automobile firm decides to spend a lot of money in research to obtain a better chrome for its cars. Their only purpose is to make the car prettier. The better chrome adds nothing to safety; there is no sociological value. In the view of the manufacturer, all it does is make the car more saleable. Let us say the manufacturer came up with a lighter kind of chrome for his car; would you give any tax exemption for that kind of research?

Mr. Mackenzie: I would be inclined to err on the side of giving those incentives rather than not giving them, because I think the main function of a general industrial research assistance program—and by that I mean a deliberate program by the Government—is to try to encourage research and to improve the "climate" so that there can be a lively kind of research atmosphere at all times. I would be very liberal in the interpretation of that. I would not be too concerned about smaller details, because I think the chances of doing purely frivolous research are fairly small. The amount that would be wasted would be very little, I would think.

Senator Grosart: It depends, of course, on what you mean by frivolous.

Mr. Mackenzie: I believe most of the manufacturers who embark on programs to spend a substantial amount of money do try to improve their products, whether merely for the purpose of making their products more desirable to the customers or in order to make them serve better and last longer. Most of that research is pretty serious minded.

Senator Grosart: Whether it is true or not, we also from time to time hear of deliberate obsolescence research. What would you do with this type of research in respect of tax incentives?

Mr. Mackenzie: Well, I do not know. This is a subject that I hear talked about, but I really have no concrete examples that I can point to.

Senator Grosart: All I am trying to get at is how you control this if you do not have some prior checkup on the amount of research that a company is going to do, and is going to claim for in respect of tax exemption. It seems to me that there would be a very difficult situation if at the end of its financial year a company prepares its financial statements on the assumption that certain items are tax deductible. As anybody who has had experience with the Department of National Revenue knows, they are not easy to get along with. Suppose they say, "No, no"?

Mr. Mackenzie: Well, if it is written into the law then there lies an appeal to the courts on these questions. I simply believe that in this area decentralized decision-making is terribly important, and it is undesirable to set up an alternative system of a group of wise men in Ottawa to evaluate things. I think the chances of loss arising from an improper use of such a system is a small price to pay for the very real stimulation you will get from a decentralized decision-making process.

Senator Grosart: There is one last question that occurs to me at this moment and it is with respect to this so-called nationalisn. You say it would be very unwise in this field of R and D to discriminate against what you call the international companies. What happens if the international companies discriminate against Canada? You mentioned, for example, that in the case of pentaerythritol it is quite possible that if the rate of taxation is not acceptable to the company they might pull out of Canada. Looking into the future, the proportion of the gross national product that the international companies will be responsible for is frightening—at least, to me it is frightening.

Mr. Mackenzie: That is right.

Senator Grosart: It frightens me to consider the position that a country such as Canada might be in. What you are saying is that we must not discriminate against them, but if they do not like the social and political decision in Canada to raise the corporate tax to 54 per cent then they may pull out, despite the fact that they might have received the benefits of certain tax incentives. The Canadian public may have paid for their research, such as in the Edmonton case, and they can take it away tomorrow. Surely, there must be a *quid pro quo* here. We are not to discriminate against them, but how are we to prevent their discriminating against us? Or, how does Trinidad and Tobago, or any other country, protect itself? I ask this question because you made a very strong point of it. I am not being chauvinistic about this.

Mr. Mackenzie: No, no.

Senator Grosart: It is interesting to hear you say there has to be this non-nationalistic type of policymaking, and that we are not to say it is to be for the benefit of Canada. It is interesting to hear you say that you do not like this policy that it must be for the benefit of Canada. I do not understand that.

Mr. Mackenzie: Well, on this whole subject of international companies there is, I think, a tremendous area that needs a great deal of study. I believe personally that there are ways of going about getting some degree of control; of recognizing the international companies as a fact of life, and finding some form of international agreement that will control their behaviour. I believe it is not beyond the realms of possibility. This is a very big international subject. It is nothing that Canada itself can do, but I think something can be done which would control, in the interests of the small countries, the fantastic effect that is going to come about by the development of these international companies, based largely in the United States, because of the extent that they are used as instruments of United States policy around the rest of the world. The problems that are arising between Canada and the United States are going to be repeated time and again in other countries as they progress in their development. We can see it beginning in Europe, and so on, now.

What I am really saying, I think, is that we ought to recognize that these international companies are a fact of life; that they have tremendous research organizations. We have access to all of that information, and we should not discriminate against them, in my book, as against a Canadian company in matters of research.

There was a philosophy here that we had good Canadian companies, we had bad Canadian companies, and we had middle Canadian companies. If you were a good Canadian company you were owned 100 per cent in Canada. If you were a bad Canadian company you were owned 100 per cent outside Canada. If you were a middle Canadian company you had a 25-50 per cent Canadian ownership. I think that that was a great mistake in the whole approach to this thing, when you are talking of a field like industrial research.

It is perfectly true, I suppose, that in the case of R.C.A., for instance, which is a wholly-owned subsidiary in Canada, the directors in the United States could make a decision to pull out of Canada entirely. But, they are not likely to do that because they have a very good and viable business here, and they make some money up here. So, there is no real reason why they should pull everything out.

The Chairman: But do you not think your argument would be much stronger if you were to say that industrial research should not be for the exclusive benefit of Canada? I refer to the illustrations you have given. You have mentioned cases of where Canada benefited.

Mr. Mackenzie: That is right.

The Chairman: I do not think the objective should be something for the exclusive benefit of Canada, but, surely, if there is no Canadian benefit at all in a project, or in a program of research, then I do not see why the Government should spend money on it.

Mr. Mackenzie: I quite agree, but it is this exclusive feature. There is a suggestion that it has to be exclusively for Canada.

Senator Grosart: I want to make it clear that I agree with you entirely. There is importance to Canada in the research that is available to us not only from abroad but in the research facilities that such companies make possible in Canada, and which provide training for our people. I agree with you entirely on that. I only raise the question of the possible consequences of one of your suggestions. That is all, Mr. Chairman.

Senator O'Leary (Carleton): Mr. Mackenzie, getting away from the international aspect of the matter for the moment, I should like to ask you how much sharing there is in Canada of the results of industrial research by purely Canadian companies. For example, if MacMillan Bloedel, which is a wealthy company, can afford certain research, and it discovers some new, better, or more efficient means of production, would they share that new knowledge with their competitors—with the Fraser Company, for example? If they do not, is there any way of making them do so?

Mr. Mackenzie: Well, in my experience the pulp and paper industry which you have picked is one industry where there is a fantastic exchange of information between all the companies, be they American-owned or Canadian-owned.

The Chairman: Yes, they have joint research.

Mr. Mackenzie: Yes, they have a joint research operation, as you know, which is supported in large measure by the Government. But the situation is quite different from that which prevails in say the chemical industry. The pulp and paper industry will let people from other companies come and visit their mills, see their machinery in operation, look at their new developments, and so on. There is an amazing interchange of information, so I do not think there is really a problem in the particular industry you have mentioned.

Senator O'Leary (Carleton): Will that apply to Alcan, International Nickel, and some of the other industries?

Mr. Mackenzie: I think the pulp and paper industry is quite different from the others—from the chemical industry and the mining industry, and so on, where there is much more concern about the proprietorship of new developments.

Senator Aird: Do you have any opinion as to why there is a difference?

Mr. Mackenzie: The chairman suggests it goes back to the thirties. It is an industry that went through an awful lot of trouble. Perhaps it is because the end product is very much the same; newsprint is pretty much newsprint when you get down to it, and pulp is pretty much pulp in the international market as distinct from a lot of chemical products and more exotic minerals and things like that. I don't really know.

Senator O'Leary (Carleton): Could there be any system devised by which government or the state could in some way say that industrial research results should be shared? By this I mean pure research and pure science. Everybody knows that if a university discovers something it is made public and all the world knows about it, but in industrial research how do they get some uniformity of benefit?

Mr. Mackenzie: I don't think they do.

Senator O'Leary (Carleton): You don't. It could well be that a good Canadian company could be put out of business by another bigger company having better industrial information. What could the Science Council do about that?

Mr. Mackenzie: That is the way the game is played. That is the system we operate under.

The Chairman: I suppose the only way is through the licensing of patents.

Mr. Mackenzie: But that gets into the whole area of patents which is a complex subject.

Senator O'Leary (Carleton): If the Government of Canada is going to go in for industrial scientific research and the result is that some large competitor puts another competitor out of business, I don't see any results for Canada in that. I would not want to be a party to enabling some rich company to get even richer because of its industrial research.

Mr. Mackenzie: I don't think the objective is to put some other company out of business.

Senator O'Leary (Carleton): But it happens, and it could happen. If the fruits of industrial research are merely to build up some powerful company to make it more powerful, I submit that in my opinion that is not good enough. We should not concern ourselves with that.

Mr. Mackenzie: I would not use the word "merely". That is not the important purpose.

Senator O'Leary (Carleton): But it could be one important result. Is there any way of guarding against that?

Mr. Mackenzie: In a competitive situation?

Senator O'Leary (Carleton): We have done a lot about other competition. In fact in the last 30 years we have done nothing else but try to destroy competition. Why stop there? This is a very important field so far as the nation is concerned; industrial research affects our export trade and world trade. Are you telling me that this is the way the game is played? If some huge firm ilke Alcan or International can by industrial research put their competitors out of business, you say that is O.K.? You say it is the way the game is played?

Mr. MacKenzie: Senator O'Leary, I don't know that I said exactly that. I said there could be some casualties in this.

Senator O'Leary (Carleton): And we take no steps to protect ourselves against such casualties? Are there any steps we could take? I don't believe there are.

Mr. Mackenzie: I don't know of any I would recommend. There are certain built-in provisions in the laws to try to deal with the situation. But your approach presupposes that the objective of these large companies is to put little people out of business. This is not the objective.

Senator O'Leary (Carleton): But they might be big people. They might try to put Consolidated Paper or Fraser out of business or put them in the position where they wished to God they were not in business.

Senator Grosart: You say industrial research is a function of big business. I would say that perhaps this is the point Senator O'Leary is making, that if we are going to put public money into creating a bigness, and tax incentives involve public money, that can be deleterious to other citizens or companies, legal citizens, isn't there some way or some means of dealing with this? If a decision is made to go ahead with any particular kind of industrial research and claim public payment for it, which is what a tax incentive scheme is, isn't there a great danger here?

Mr. MacKenzie: It seems to me it is not a question of whether we like it or whether we do not like it. The facts of life are that the major research efforts in this day and age are likely to be undertaken by the larger companies. One obviously does not want to do anything to prevent a smaller company growing to the point where it can play in that league, but I think you will have to admit that the bulk of this major industrial research effort is by larger companies. It is not a question of whether they are Canadian or American companies, and if you accept that, then it seems to me the system ought to be to encourage these companies to do it by a tax incentive program that is open to everybody.

Senator Grosart: But is it open to everybody? First of all you have to find the capital, and big companies have the capital. This may not be the case with small companies.

Mr. Mackenzie: Well, everybody that is qualified to get in and play in that league.

Senator Grosart: But is there not a big difference between that and the situation in the United States where, for example, under NASA they say to a small company "Here is the money to do some particular research." The big companies already have the capital which they can spend and then claim. There must be many small companies who cannot do this, and this is my concern.

Mr. Mackenzie: Let me make it clear that I am talking here about one part of the Gov-

ernment's program which can stimulate research. One thing they do, and it is expensive to do it, is to maintain for themselves extensive research facilities like the National Research Council and the other research activities that go on in government. Another aspect of it is contributions to universities, hospitals, medical research and all the rest of it. There is also sponsored specific project research. The Defence Research Board may come up with some idea that they want a particular company to develop for them. It is not a question of size but the question of the individuals concerned and their ability. But apart altogether from these aspects I say there should be a general incentive scheme for general industry, not to the exclusion of these other things but in addition to these other things, and the general approach that I would recommend would be a tax deduction approach as opposed to a system of approval of individual projects.

Senator Grosart: Do I understand you are not recommending this tax incentive as the whole Government policy in respect of industrial reearch?

Mr. Mackenzie: No, surely not. This is one aspect of it.

The Chairman: Do you think it will be possible also to further encourabe co-operative effort in industrial research in smaller companies or smaller firms?

Mr. Mackenzie: I do not know about this, I am not at all sure such plans will work. There are certain areas in which it is abundantly clear that the research has to be done in a centralized place. Agriculture is a very good example. You cannot expect an individual farmer to set up a research establishment; that can be done only by some organization. The same applies in fisheries and so on. However, when you get to industrial research, pulp and paper seems to be able to do this but whether it is practical in any other industries I am not at all sure. I have yet to be satisfied on that score. I do not think so.

Senator Aird: One of the problems we have discussed at previous meetings is the difficulty in taking inventory in the ever-changing technological scene. Presuming the validity of your point that the Government should have no control over the inception of R and D, for instance in Chemcell, do you think there comes a point when there should be a sharing of this? Previously I asked why the paper industry was related to the chemical industry. I think there are many self-evident answers, which you have now given. From the Canadian point of view a multiplicity of products is emerging. It seems that in the chemical industry there are overtones of other kinds of facets and usages; certainly arms, ammunition, emanate from the chemical industry.

Given that background and our problem of inventory—I hesitate to use the word "control" because I am not sure that is what the Government is looking for, but perhaps direction; the Government is addressing itself to the problem of direction—do you not think that at some stage, even for a company such as Chemcell, there gets to be a sharing, a disclosure, so that people can know and make up their minds, so that in effect the Government can make up its mind about the priorities you discuss in your brief?

Mr. Mackenzie: I quite agree. Chemcell, for instance, at one time had three or four individual projects which had been approved by the National Research Council, of which the Government was sharing about half the cost. They were projects we dreamed up, if you like, which went to the National Research Council who felt they were useful and were prepared to go along with them. That is a highly desirable part of this program. I am saying I do not think the whole of government encouragement for industrial research should be based on that approach, where you need individual approval of the individual projects. I think that over and above that you need this general incentive which we had until a few years ago.

Senator Aird: I am presuming the validity of your argument and that at its inception your R and D should go forward, because I happen to agree that there are not too many frivolous research enterprises undertaken by industry generally. However, there gets to be a stage—and I think this is the centre of our problem—of deciding what can be done to effect this common knowledge with the priority that we are seeking. This follows on Senator O'Leary's (Carleton) line of questioning. It seems to me that we do get to that stage.

Senator O'Leary (Carleton): Would there be a solution in the company reporting its findings to the National Research Council?

Mr. Mackenzie: On projects which are specifically approved obviously they report their findings to the National Research Council.

Senator O'Leary (Carleton): But are they compelled to report, or should they conceal?

Mr. Mackenzie: I do not think so. Frankly, I am not equipped to answer that in detail. I believe the results of that research accrue to the company itself, but I think the knowledge of it goes to the National Research Council.

Senator Bourget: Could it be spread around after that, or should it just be given to the company?

Mr. Mackenzie: I think you would have to ask somebody from the National Research Council how that system works. I am not up to date on this now and am not competent to answer. It was my understanding that if something patentable came out of this research Chemcell would in fact own the patent. Once you get a patent on something it is still available to other people, but they have to pay for it. I would suggest that you get the details of that plan from the National Research Council because I am not sufficiently well informed on it.

Senator Yuzyk: Do any aspects of industrial research come under security regulations? I take advantage of the fact that you are chairman of the Royal Commission on Security. I understand that in the very near future the report will be tabled in Parliament. Is there anything in the report about science policy in connection with security?

Mr. Mackenzie: I do not think I can here discuss what is in the report. The report has not yet been tabled.

Senator Yuzyk: I am asking in just a general way. Does it deal with science policy at all? We will get the report when it is tabled.

The Chairman: But we do not have it.

Mr. Mackenzie: We do not have it at the moment.

Senator Robichaud: At one stage of your argument you say that we should accept and not be afraid of the international implications of research. I cannot agree with you more on this conclusion. Would you also be in favour of the exchange of scientific data with foreign countries, and even go further in certain fields and favour the exchange of scientists? For example, foreign scientists would come over to this country for a certain term, while some of our scientists would go to other countries in order to become more familiar with the international aspects.

Mr. Mackenzie: This is one of the benefits that comes from these international associations. Reverting to my own experience in Chemcell, I remember that we had on our staff a very able man, who incidentally had worked in Ottawa in the research field for some time, who went to the United States for a period of three years and worked full time in their research organization, where he distinguished himself. He came back here and headed up our whole research business. He was a very much better man for having had three years' experience in the United States laboratories. This interchange is possible and is one of the great advantages which comes from these close relationships. I am not suggesting these are the only things that make this country tick, but I say that when the opportunity is available to us we miss the boat if we do not encourage them.

Senator Robichaud: Would such an exchange not also be financially desirable in, for example, fisheries, in research on species like herring? I know that in Canada we are far behind, we are not as advanced as other countries in this field. The U.S.S.R. are well advanced in herring research and if we could benefit by getting their data and knowledge it would certainly be beneficial to our industry.

Mr. Mackenzie: There is no question about that.

Senator Robichaud: I do not think our Government is in a financial position to obtain the know-how to get as far advanced as the U.S.S.R. is in this field; it would take years of research to get to that point.

Mr. Mackenzie: I think my main point is that, if one can get in Canada a climate that is conducive to stimulation of research in all of these areas or phases, individuals will then come bubbling up with ideas and they will pick up information from international sources around the world and you have a much more lively industrial activity.

The Chairman: Is there a similar scheme of tax incentive in the United States for industrial research?

Mr. Mackenzie: I do not think so but we had it in the Income Tax Act for a long time

and it seemed to me that this was a better based scheme than the present one of grants in aid.

Senator Lang: If we revert to the general tax incentive that we had in the Income Tax Act a few years ago and with the proviso that any company claiming those deductions could not patent the results of the research done, what effect would that have on companies taking advantage of that setup?

Mr. Mackenzie: I think it would kill them.

Senator Bourget: From the example you have given us, when you took over the research, the preliminary research made in the United States, did you act to bring in researchers from the United States to Canada to help develop this project?

Mr. Mackenzie: No. It was done very largely by people already on our staff. I do not mean that there was not an exchange between people, but the group we had in Edmonton was recruited—I cannot think of anybody who was not a Canadian.

Senator Bourget: Did you find it difficult to get good trained men for research?

Mr. Mackenzie: It is difficult but it is possible. We were very fortunate because we got off on a very good foot. When Dr. C. J. Mackenzie retired as chairman of the National Research Council, I persuaded him to join Chemcell and his mere presence there attracted a lot of good people to it. This is what attracts good research people—to be working with people who are knowledgeable in this field. He had retired from the Research Council activities but he then devoted a lot of time to building up our little research organization in Edmonton. It was small but very very good.

Senator Bourget: Did you send them to the United States or somewhere else to get better trained?

Mr. Mackenzie: We did not send them to universities. There was a continual interchange in the research establishments of the same nature in the United States, people going backwards and forwards all the time, exchanging notes. But these were all qualified people who had Ph.D.'s and so on: they were not people going back to university.

Senator O'Leary (Carleton): Do American companies as a rule supply scientific information to subsidiaries in Canada? Is this the rule or are there exceptions?

Mr. Mackenzie: I suppose there are exceptions but certainly in my experience a great many companies have this access to the research of their parent company.

Senator O'Leary (Carleton): If they became competitors of the parent company in world markets, would that rule still apply?

Mr. Mackenzie: What they do with the product is probably a different field, but on the question as to whether they have access to the information, I would say most of them have access to the information.

Senator Grosart: In the Edmonton case, you told us that the parent company or the international company took over the American market, for obvious and understandable reasons. What is the position about the 30 or 40 other markets that you mentioned? Are they not likely to say that the American branch or the American plant will take over, if conditions are favourable to those 30 or 40 markets, from the Edmonton plant? Is this so?

Mr. Mackenzie: I suppose these things could happen. I do not think they are likely to happen, because there is a very substantial investment in this plant in Edmonton and it is in everyone's interest to keep it viable and profitable. It would not make any sense if the parent company took all this business away. Chemcill has Canadian shareholders as well, it is not 100 per cent American owned. We lost the American business because the parent decided to put in their own plant. If they had not, someone else would have done so.

Senator Bourget: Are you producing the same product at a cheaper price than is the United States?

Mr. Mackenzie: I do not know if it is cheaper but there is a tariff in the United States, a tariff of 12 per cent I think. We still have these worldwide sales to 35 or 40 countries and we have every reason to suppose that they will continue, based on the economics of the situation.

Senator Grosart: What troubled some of us is that it seemed obvious that the decision will be made in relation to the interests of the international companies as such rather than in the interests of Canada.

Mr. Mackenzie: This is an ever present worry but it is something that comes with the

existence of international companies. I think it is one of the prices you pay for having the international companies operating here. I do not think it is too big a price to pay, I think we fare well, very well, but one cannot deny that this is a hazard.

Senator Grosart: As you say, we have to accept the facts of life—and on balance you would say that Canada has benefitted rather than otherwise?

Mr. Mackenzie: I do not think there is any question about that. I am hopeful we can develop some international companies. Right now we have some. We have Massey-Harris as a case in point, where the control is in Canada but the operation is spread around the world. There is also MacMillan, Bloedel, which is getting to be an international company. There is hope we might build up more ourselves. International companie are a fact of life and there is nothing we can do to change that.

Senator Grosart: It is suggested that one of the things this committee should do is to make a recommendation to the Government as to the total amount of money that the Government should be putting into R and D perhaps in terms of percentage of GNP. Do you think that makes sense, to make a set recommendation, or that the Government should adopt a policy of a minimum amount that it would put into R and D; and, if so, how could this be controlled under your proposal of tax allowance.

Mr. Mackenzie: I do not know how it could be controlled, because basically what I am suggesting as far as industrial R and D is concerned, is to rely on the individual decisions of individual companies. In that sense, you have not got control. The absolute amounts involved would probably be relatively small in relation to the total amount of the Government's effort in R and D, because this is only one aspect of it. I would think the bigger it gets, the better. I would like it because it is all coming out of profits. What I am talking about is not a commitment, you do not have to pay out money: it is a question of percentage of taxable profits which you take in the future.

Senator Aird: I wonder if you are familiar with the excellent article by Joan Fraser, which appeared in the *Financial Times* on Monday last. It ends up by posing a question or making a proposition, that the choice may be that Canada should set up in effect a Ministry of Science and Technology or that under the Science Council it could go forward to co-ordinating other industries. I wonder if you would have an opinion between the two choices?

Mr. Mackenzie: I do not know if my opinion is worth very much.

Senator Aird: Speaking from your background, sir, and from a competitive point of view, as one having been in business and who has been faced with the problems on an every-day basis, which do you think might be more compatible or more desirable?

Mr. Mackenzie: I would much sooner see this co-ordinated, that is, the government getting advice through the science council rather than through a minister of science and technology. Personally I think we have enough ministers and departments.

The Chairman: That might be.

Senator Grosart: In the first paragraph on page 7 of your submission, Mr. Mackenzie, you make a suggestion that a body of independent government advisers be drawn from those with established expertise in the field, supported by a suitable secretariat. Is this a suggestion for something in addition to the science council and science secretariat?

Mr. Mackenzie: Oh, no, this is the science council and science secretariat. The science council is comprised of people from industry, universities, and the public service who have a knowledge of the subjects. They are not all civil servants. The whole concept was based on recommendations by C. J. Mackenzie originally.

Senator Grosart: Do you prefer the American rather than the European system?

Mr. Mackenzie: I find it difficult to see there is a job for a minister of science and technology, because his duties would cut across responsibilities of many other ministers.

Senator Grosart: Britain has one as well as, most European countries.

Mr. Mackenzie: Yes, I know they have, but I find it difficult to see how they do it. There is inevitable conflict between the ministers who have the responsibility for these operating divisions.

Senator O'Leary (Carleton): Would it not be a good idea to have a minister in the House if only on Sundays to answer questions? By the way, what has happened to our science council? I saw one report which consisted only of their names and their pious hopes and aspirations. Has there been a second report?

Mr. Mackenzie: I think I said the science council has not had time to show what they can do. I am in favour of there being such a body.

Senator O'Leary (Carleton): So am I.

Senator Cameron: In your experience with Chemcell and other related activities, have you found any problem caused by the interpretation or by the taxation division as to how they would treat new products and new processes. I have a specific case in mind. A group of young Canadian engineers in the computing field developed a means of carrying out geophysical studies and this is revolutionizing the geophysical exploration work up north. The taxation division came along and said to these men, "look, we are going to tax the product of your data processing machine". This would mean applying about a 12½ per cent tax on the product, that came out of the machine, about the difference between a profit and no profit. Recognizing that American companies have their own resources in various parts of the United States, such as Houston, Dallas and one in Oregon that could have put this young Canadian company out of business, I asked these people in the Sales Tax Division on what basis they arrived at the right to tax. I was told it was based on section 1 in the act of 1954 before any computing equipment was in being.

I wonder if this same principle has extended to other cases and other products. If so it underlines the fact that there is a need to up-date a lot of our legislation in government departments in terms of new technology.

Mr. Mackenzie: I think there have been many difficulties with these definitions. There was considerable controversy over the question of what was a new product and whether it was new to the company or its management; alternatively, was it something completely new in the sense that nobody had ever seen it before? There are many arguments similar to this. We went into this at some length in the report of the Economic Council on the definition and came up with recommendations—I think it was the D.B.S. definition that was the most appropriate, with some minor amendments. There have undoubtedly been problems in interpretation.

Senator Grosart: I watch television and read the ads, and I think everybody in business claims everything is new.

Senator Cameron: This could have a very serious effect on Canadian companies. It may be that in Canada the consumer has a choice to bring in products from the United States until such time as we develop this new industry ourselves; however, it could be completely inhibited by the interpretation of the taxation division.

Mr. Mackenzie: The definition is very important but I maintain it should be a definition rather than a series of administrative judgments.

Senator Cameron: We get a lot of administrative judgments in this country.

The Chairman: It seems to me that you would still have administrative judgments in the interpretation of the definition, even supposing that the definition is perfect.

Mr. Mackenzie: That is right, but then you have the system of contesting interpretations in the courts.

Senator O'Leary (Carleton): Do you wish a guide for your conscience?

The Chairman: I suppose that you also could have consultation before you start for protection to see whether or not you are elegible in dubious cases.

Mr. Mackenzie: This happens now in respect to income tax problems where people can discuss their problems with income tax officials. They cannot receive a definite ruling, but they can get an idea as to whether they are on the right track.

The Chairman: Are there any further questions? On behalf of the committee, sir, I want to thank you very much for this most interesting presentation and discussion.

Mr. Mackenzie: Thank you very much.

The committee adjourned.

First Session—Twenty-eighth Parliament

1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
SPECIAL COMMITTEE
ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*

The Honourable DONALD CAMERON, *Vice-Chairman*

No. 2

WEDNESDAY, OCTOBER 9th, 1968

WITNESS:

Dr. Jacques Spaey, Secretary General of the *Conseil national de la politique scientifique* (National Scientific Policy Council) of Belgium and Chairman of the *Commission interministérielle de la politique scientifique* (Interdepartmental Scientific Policy Committee).

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

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MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

WEDNESDAY, October 9th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.30 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Kinnear, Lang, O'Leary (*Carleton*), Robichaud, Sullivan and Yuzyk—(13).

In attendance: Philip Pocock, Director of Research (Physical Science). Gilles Paquet, Director of Research (Human Science).

The following witness was heard:

Dr. Jacques Spaey, Secretary General of the *Conseil national de la politique scientifique* of Belgium and Chairman of the *Commission interministérielle de la politique scientifique.*

(*A curriculum vitae of the witness follows these Minutes*)

At 5.20 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Spaey, Jacques. B. December 23, 1908 in Ghent. Nationality: Belgian. Marital status: married, 6 children. Residing at: 16, avenue Alphonse XIII, Uccle, Brussels 18, tel. 740217. DEGREE: Doctor of Medicine, University of Ghent 1933. KNOWLEDGE OF LANGUAGES: spoken and written languages, French, Flemish; spoken language, English; language understood, German. POSITIONS HELD: Foreign assistant at the University of Paris 1933-34. Assistant at the University of Ghent 1934. Chief of service at the Etterbeek Hospital 1939. Executive Assistant to the Minister of Public Health 1947-48. Président of the *Office Médico-légal* 1951-1955. Officer in the Office of the Minister of National Defence responsible for personnel management 1958-1959. Advisor to the *Centre d'études sociales de l'armée* 1959-1961. Executive Assistant to the Minister of the Interior and of the Public Service 1961. PRESENT POSITIONS: Secretary General of the *National Scientific Policy Council.* Chairman of the *Interdepartmental Scientific Policy Committee.* MISSIONS AND TITLES: Belgian delegate to the World Health Organization 1948. Mission to the Congo for the Minister of the Colonies 1949. Delegate of the *Conseil belge du Mouvement européen* to the Economic and Social Conference of Westminster 1953. Belgian delegate to the XVIIth Session of the Economic and Social Council of the United Nations in New York 1959. Member of the *Conseil supérieur d'hygiène.* Member of the *Conseil supérieur de l'assistance et du service social.* Member of the *Conseil supérieur de la Famille.* PUBLICATIONS: *Biological and medical sciences. Méthode colorimétrique de mesure des polypoptides du sérum,* excerpt from the minutes of the meetings of the *Société de biologie* (meeting of February 17, 1934, Vol. CXV, p. 711). *Post-operatiefsyndroom, overgedrukt uit Geneeskundige Bladen uit België, 2ᵉ jaargang,* No. 10, 1934, blz. 198-204. *Corps étranger gastrique, repérage radiologique et radioscopique,* excerpt from the *Journal belge de Gastro-Entérologie,* No. 9, November 1938, pp. 664-667. *Human and social sciences. Médecine sociale,* Tournai, Paris, Casterman, 1945. *Collection "Bâtir"* 142 p. *Le droit à la santé, Revue nouvelle,* 1st year, No. 8, May 15, 1945, pp. 495-502. *Geneeskundig en sociaal dienstbetoon, overdruk uit "De Gids op Maatschappelijk Gebied",* No. 6, juni 1946, 10 blz. *Statistiques d'un Centre de santé interpatronal,* excerpt from the *Acta Medicinae Legalis et Socialis,* No. 1, 1948, 31 p. *Médecine sociale et Droits des Personnes,* Rome, 1949, *extratto dagli Atti del IV Congresso Internazionale dei Medici Cattolici,* 3 p. *Positieve Eugenetiek, Overdruk uit Sint-Lucasblad,* No. 3, 1950, Leuven. Congo 1949, *Revue Nouvelle, 6ᵉ année,* Vol. XI, No. 2, February 15, 1950, pp. 178-183. *Initiation à la Médecine sociale,* Tournai, Paris, Casterman, collection *Leçons familières,* 1951. *Santé et Politique, La Revue Politique, 1ʳᵉ année,* No. 2, December 20, 1951. *L'aspect médical médico-légal et médico-social de la notion d'invalidité,* excerpt from the *Acta Medicinae Legalis et Socialis,* No. 3-4, July-December 1952, pp. 215-226. *Le médecin et la médecine en Droit international,* excerpt from *Scalpel,* No. 29 of July 18, 1953, 4 p. *Orientation scolaire et professionnelle, La Revue Politique, 3ᵉ année,* No. 2, April 25, 1953, pp. 167-174. *Die Zukunft der christlichen Demokratie, Dokumente, 10. Jahrgang, Juni* 1954, pp. 205-219. *Santé publique et assurances sociales, La Revue Politique, 8ᵉ année,* No. 2, October 10, 1959, pp. 185-194. *Problèmes humains du travail: une session d'étude de la*

C.E.C.A., La Revue Nouvelle 15e année, Vol. XXX, No. 7, July 15, 1959, pp. 72-75. *Techniques Humaines. La gestion du personnel dans les grandes unités industrielles et administratives. Éditions de l'A.P.I.C.,* 1961. *De aanpassing van de methodes en de programma's aan de moderne levensvoorwaarden, Vorming, jrg.* III, No. 3, September 1962, blz. 139-144. *La nature de la gestion et de l'organisation.* In: *Reflets et perspectives de la vie économique,* Vol. III, No. 2, April 1964, p. 113-117, separate reprint. *Political science. La fonction de l'université, La Revue nouvelle, 17e année,* Vol. XXXIV, No. 10, October 1961, p. 257-264. *Le droit de cité de la recherche dans l'entreprise et le statut du chercheur industriel, Conseil économique wallon,* No. 57, July-August 1962, p. 1-6. *La carrière du chercheur, Alumni,* XXX, April 1962, p. 7-14. *Vers une réforme de l'enseignement secondaire, Éducation,* No. 77, September 1962, p. 81-85. *La programmation de la recherche, Bulletin de documentation—Ministère des Finances,* No. 7-8, July-August 1965, p. 49-64. *Ce que fait la Belgique pour la recherche; ce qu'elle souhaite sur le plan international, Les Échos,* Paris, December 21, 1965.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, October 9, 1968

The Special Committee of the Senate on Science Policy met this day at 3.30 p.m.

[*Translation*]

The Chairman: Honourable Senators, this afternoon we have the honour and very great pleasure of meeting Dr. Jacques Spaey who generously agreed to come to speak to us today on science policy.

Dr. Spaey, a medical doctor by profession, has devoted his life, particularly since 1947, to the Public Service of his country. I do not intend to describe to you all the details of his life, as his biography will appear in the proceedings. However, I would like to mention that he is presently the Secretary General of the National Scientific Policy Council of Belgium and also the Chairman of the Interdepartmental Scientific Policy Committee.

[*English*]

Thus, Dr. Spaey is really at the centre of the scientific effort of his country. I am sure he will want to speak to us about that effort. This, of course, will be most useful to us, because we in Canada have similar problems to face, not only in the field of science policy but also in other fields.

I assume that Dr. Spaey will make part of his presentation in French, but I understand that he is at least trilingual, so that he will be able to handle any question that you may want to put to him.

Dr. Jacques Spaey, Secretary General, National Scientific Policy Council; Chairman, Interdepartmental Scientific Policy Committee, Brussels, Belgium: Mr. Chairman, my English is too poor to explain such difficult questions as those with regard to science policy and science generally.

So I ask your permission to explain it in French, and I will begin with some general ideas about science policy; and after that I should like to hear your questions on these problems and give you answers.

[*Translation*]

Mr. Chairman, scientific policy is a rather recent notion and probably an equivocal one at that because it is so recent. We may wonder, when we speak of scientific policy or "science policy," whether we mean a policy for science or indeed a policy for organizing science so as to attain a certain number of economic and social objectives.

However, although this question has not been resolved in theory, we may state that in fact—and this was clearly shown in the recent O.E.C.D. report in Paris—science has assumed an increasingly important place in the development of societies generally and of highly advanced societies in particular.

This results from the fact that following the American lead, our industrialized societies entered into a phase of development through innovation: innovation in industrial production; innovation in the management of public and private organization, and the use of revolutionary new methods in all fields of human activity.

Innovation stems from science, particularly scientific research, which itself is at the origin of new methods and new concepts which are taught today and will be taught tomorrow in the universities.

A major difficulty arises from this development. Men of science, while perfectly aware of the importance of their own activities, are not always conscious of the actual importance these activities assume in society and above all, of the significance of science in the present world.

This is a prevailing phenomenon, and I feel it would be useless to argue the point. Progress in development, particularly its influence in American society, can be explained by no other fact than the opportunity this society has of putting to use scientific innovation. It is not that Americans are much more intelligent than other people, but that they have the means and are in a position to make greater, quicker and better use of all elements of the second industrial revolution. The first consisted of developing natural resources; the second consists, above all, of developing our grey matter. This is the phenomenon with which we are concerned.

The second reason why a scientific policy has appeared in industrialized countries is that public funds devoted to higher education and research have rapidly increased during the past ten years. In my country, the public budget for higher education and research has increased five-fold since 1960. This remarkably rapid increase in scientific budgets has worried finance ministers; and everyone is aware that when the Minister of Finance or the Minister of the Budget is worried, the government is worried.

A government's first thought in the face of such developments is to consider whether the rate of expenditures cannot be reduced. However, if government officials in this particular field emphasize that it is no doubt possible to put these growing expenditures to better use, then we are dealing with a concept more accessible to politicians and governments, namely: if a certain development cannot be prevented, it must be at least guided in the right direction. This is the concrete and more immediately political aspect of scientific policy which must be emphasized. It is for all these reasons that political science institutes have appeared in the majority of the industrialized countries over the past ten years, institutes whose purpose is to organize the development of science in order to attain a certain of national objectives which the Americans call "national goals". This poses difficult questions for all governments.

The first difficulty resides in the psychology of the scientific community which traditionally considers that science cannot be dominated or influenced by probable results. We all know that it is a sort of rule in the scientific world to consider that the great merit of science is that it is "free". However, we cannot help but note that progress in the sciences over the past twenty years has been largely influenced by a parallel progress in technology and that, in reality, we are in a world in which every human endeavour influences and enriches another.

It has often been proven that from the needs of technology, the most important fundamental discoveries have been made. The reverse is equally true. In any case, whether we want it or not, science is to some extent caught up in history. It is caught up in a human adventure, and it must be impressed again and again upon men of science that their requirements for development are so great and so costly that they can only be obtained to the extent that there is a rapid increase in the national product, and that the national product can increase rapidly only to the extent that science assists in its growth. Consequently, it is through a mutual enrichment of science on the one hand and organization on the other that both may succeed.

However, on the side of the government or parliament, this mutual co-operation poses difficulties because the administrative structure of our states is not often adapted to coping with this particular problem. In the field of scientific policy, it is not merely a question of efficiently handling the files but of drawing up logical forecasts and attempting to determine goals for our modern societies to be attained within ten or fifteen years, and to assess to what extent these objectives may be reached through scientific activity and technological development. It is a particularly difficult type of problem which calls for methods far beyond the present methods used by our administrations; it calls for the establishment of special organizations to handle these problems.

But should these organizations be entrusted to men of science or to managers? My reply would be that we must avoid cut-and-dried solutions. Probably managers alone could not effectively handle difficult questions, and men of science alone would be equally inept at arriving at completely satisfactory solutions, just as military problems are not always perfectly solved by military men themselves but within a wider political framework.

How can we reconcile these two difficulties; how can we solve this problem? I feel I should point out that there are several possible methods, but none of them is perfect, and each country must find it own. Having enjoyed your hospitality which has been both very cordial and most frank—and it is extremely rare to meet both men of politics and civil servants with whom one feels one can talk directly and frankly—having seen and heard what I have in Canada, I would say that you have made very great efforts in the field of science and that you are well on the way to settling this problem, or at least to dealing with it in an efficient manner.

Allow me to say once again that we cannot look for cut-and-dried solutions in the area of policy and organization. We must be content with organizational planning for the next ten years, and even that is ambitous. We will then have to make adaptations, since the world is advancing so fast that we cannot establish a definitive organization such as the nineteenth century believed possible.

Mr. Chairman, after these few words of introduction, perhaps we could, with your permission and in answer to questions by honourable senators, go into more concrete details.

The Chairman: Before beginning the discussion period, Dr. Spaey, might I ask you to give us a brief description of the organization and structure of science policy in Belgium at the present time?

Dr. Spaey: To give a schematic view, we may say that Belgium has gone through three stages.

The first period existed before 1960, when, like most other countries, we had bodies which financed research in universities, in industry and in research centres. There was no actual science policy, in that the government had no means and no organization to take decisions or to make choices. In 1958, I believe, a Royal Commission was set up to study this problem. I do not know the reasons which lay behind the decision to set up this commission, but I expect it was prompted by both necessity and current trends.

As I have already said, all governments are sensitive to increases in expenditures; they feel troubled by such a phenomenon and they follow the example of neighbouring countries.

If I remember correctly, the Royal Commission made about twenty recommendations to the government. This commission was made up of representatives from universities, from industry, and from social and economic sectors. Among its recommendations, it suggested the establishment of a national council of higher education for research. In actual fact—and this is a Belgian characteristic—science policy encompasses higher education as well as research, and basic research as well as applied research. In accordance with this recommendation, the government formed the *Conseil national de la politique scientifique*—the National Scientific Policy Council.

The main purpose of the minister who made this suggestion to the government was to form a council, on the one hand, and a service to administer science policy, on the other. This service would be required to set up a secretariat for the council. I believe that this is more or less the situation you have here, if I have been correctly informed.

Due to political circumstances, a compromise had to be made and this resulted in a council and a secretariat, whose secretary general was appointed by the cabinet. This body began its work under very difficult conditions, since the government in power at the time felt that it had completed its duty once it had formed the National Scientific Policy Council.

This Council was made up of scientists and also of representatives from social and economic sectors. Unions were represented, as were high finance, the national economy, industry, etc. In the beginning, the Council made fairly general recommendations to the government: science should be promoted; the means available to science should be increased, and research workers should be given a certain status—in short, everything which could be said easily, without consultation. However, since they were important men, it was helpful that they spoke together. The government, occupied like all governments by many other considerations, took the reports, thanked the chairman of the Council for them, and made no use of them.

The Minister of Finance, or the minister responsible for the budget, held out as long as possible against increasing credits. This increase finally came about owing to the force of circumstances, but without much selectivity or direction. At that point, the Council's secretariat suggested that certain steps be taken, and these have proven to be very important. The first step was an inventory of the nation's scientific potential. How many research units were there? How many

research workers were there? Toward what purpose was their research directed? What discoveries had they made?

The composition of the budget for science was a second factor which was still unknown. What was the exact amount of money earmarked for higher education and for research? No one knew, because in Belgium—as in other countries, I suppose—estimates for scientific activities are swamped in the very general wording of departmental budgets. As a result, no one except the initiated civil servant can tell whether it is really for scientific activities and what aim is being pursued.

This work encountered a great deal of resistance, particularly from the universities, but also from administrative bodies. On the other hand, the industrial sector supported this initiative, which in any case made it possible to establish definitive relations. Only at this time did the government take the trouble to listen to the Council's advice. The Council told the government that it wanted such and such a percentage increase; it gave a clear indication of the actual situation and showed the uses to which the increase could be put. From then on, the government and its ministers began to read reports carefully.

The structure in science policy has been altered in the past few months because of a change in government. The council's secretariat is now one of the "Services" under the Prime Minister. It is in change of programming science policy and also of taking responsibility for technical assistance and the Council's secretariat. These measures were designed to avoid duplication of programs by the Council and the government, programs which might have been excellent on either side but which would have had the unfortunate effect of confronting the government with choices which were as difficult as they were arbitrary.

I feel that this has been an accurate summary of the development of science policy in Belgium, Mr. Chairman. It should perhaps be noted that the *Services de la politique scientifique* (science policy services) are in no way responsible for the control of funds. This is entirely the responsibility of the minister in each sector. Thus there is no Minister of Science, but a Minister of Science Policy, who prepares the government's overall decisions on choices, programs and allotment of funds, but who does not distribute money and does not manage any funds or programs.

I do not know if I have answered your question, Mr. Chairman.

The Chairman: Thank you very much. I think that it is now time for a short recess, and we will resume in about ten minutes. We will then have a question period.

UPON RESUMING

The Chairman: Order, honourable senators. Senator Desruisseaux?

Senator Desruisseaux: Before saying anything else, Dr. Spaey, I would like to thank you on behalf of my colleagues for taking this trip and being so kind as to answer our questions, which we feel are very important for Canada because of the forward-looking policy which we wish to see in the field of science. We were greatly impressed by your statement, although we found it a little mystifying. You must not be surprised, therefore, if we ask you many questions this afternoon.

First of all, your system of, I believe, a secretariat for the sciences under the Prime Minister, appears to have certain similarities with our own. We also have a Science Council, which has been formed, and a Secretariat. However, certain aspects of priority here are entirely different from what you described in Belgium. To take a concrete example, what methods or steps were used to help industries evaluate their needs, and to put into operation not an annual program but one which would offer them continuity? This is the first question I wanted to ask you.

Dr. Spaey: There are two channels through which assistance to industrial research is assured. This assistance may be complemented by assistance to industrial investments, but I am speaking only of aid to research. One of these is a body known as the *Institut d'encouragement à la recherche* (Institute for the promotion of research) and it is for industry and agriculture. This is a public law body and has two budgets, one for industry, one for agriculture. This Institute supports joint research projects by means of loans without security, which represents fifty per cent of research costs. By joint research projects, I mean projects conducted by several businesses which have joined together to form professional associations; for example, the *Centre du textile* (textile centre) or the *Centre de la mécanique* (mechanics centre), and so on. It is thus a question of subsidies to research on a Co-operative basis. In principle, these projects are designed to improve productivity; in other words, to improve products and current processes. In the latter case, one is required to publish the results. This

type of financial aid is available to all companies or groups of companies.

The other form of financial support of industrial research amounts to about 500 million Belgian francs per year, or 10 million dollars, which is used to sponsor so-called competitive research through an agency known as the *Administration des prototypes* (Standards Control). This group finances projects which are proposed by a single company, and which are of a competitive nature. The results of their research are therefore not available to rival companies. In this case the financial aid is not in the form of a subsidy, but a loan which may cover up to 80% of the cost of research. The loan never covers 100% of the cost, because we have found that if we sustain 100% of the cost of so-called competitive industrial research, we run the risk of paying out money to people who are referred to in the language of the initiated, as "shacks". If the company is not in a position to assume 20% of the risk, we do not see why the government should assume 100%. This loan must be paid back if the project is successful, and may be subject to royalties; but the royalties may not amount to more than twice the value of the loans advanced by the government.

Here the order of priority is more stringent. Top priority is given to projects involving advanced technology, proposed by companies which will be able to see the project through to the marketing stage.

Second priority is reserved for projects involving less advanced technology, but proposed by progressive companies.

Third priority is granted to projects involving advanced technology, proposed by companies which have the potential to contribute significantly to our economy.

We draw the line here, because we feel that our aim is to promote the kind of research that can directly contribute to the growth of the national economy, and we do not want to confuse government support of research with welfare. In other words, we try to support projects that are a good risk.

Have I answered your question?

Senator Desruisseaux: Yes. I have some other questions, this time relevant to our own concerns. Does the amount of $10 million, which you said is set aside for research, meet the demand? Is that amount spent each year? Is it adjusted according to need and demand? On what basis do you arrive at these budget estimates?

Dr. Spaey: The 500 million francs I mentioned earlier are used for joint research. Competitive research also receives 500 million, and priorities are established on the basis of the projects proposed by the companies.

Senator Desruisseaux: But are you able to fill all requests?

Dr. Spaey: Yes, we have managed to so far, because this undertaking is still new and the companies have not yet acquired the habit of requesting extravagant amounts. They will in time, but we shall proceed with caution, for experience has shown that if we increase our grants too rapidly, we inevitably end up by over-spending. Civil servants think they are being inefficient if they do not use up the entire amount of their grant—at least this is the case in Belgium.

The Chairman: In Canada as well.

Senator Desruisseaux: In some respects all countries are alike.

Regarding the 80% which the government contributes to a project, and the 20% contributed by the company which proposed it, is that 20% a tax-deductible expense, in view of the income it will create, or is it considered as a capital investment?

Dr. Spaey: No. We cover only the costs of research, including equipment. This means that the government will never pay over 80% of the cost of research.

Senator Desruisseaux: But is the company's 20% considered an expense?

Dr. Spaey: Yes, it is an expense. It is a risk which the company assumes.

Senator Desruisseaux: What percentage of the gross national product does the sum of $20 million represent? Is it a large proportion of the gross national product?

The Chairman: Perhaps "total budget" would be more accurate?

Dr. Spaey: Here I should point out that in Belgium, in 1969, we will spend 2 billion francs on industrial and farm research, of which 1 billion 500 million will go to industrial research. Besides this, which is the amount the government contributes, about 8 billion francs are spent on research by private industry as well. This brings the total to about 10 billion francs. Since the national product is presently about one thousand bil-

lion francs, that makes a bit less than 1%, just for industry, while the basic research is completely paid for by the government.

Senator Bourget: Is the basic research done in the universities, and, if so, does the government pay for all such research?

Dr. Spaey: Actually most of the basic research is done in the universities. There are few other research centres, except for a small number of government centres, but these government centres are really public services which include among their activities the support of basic research. For example, the *Institut de météorologie* (Meteorological Institute) or the *Institut d'aéronomie spatiale* (Space Aeronautics Institute) are federal science agencies. They could be called branches of the federal administration which perform public services. The observatory gives the time; meteorology predicts the weather, the royal library diffuses scientific information, etc.; they are public services which also do research. But apart from these, almost all basic research is carried out in the universities, and to a lesser extent by industry.

The answer to your second question is that the budget of the universities, which is entirely the responsibility of the government, is in fact, though not rightfully, proportioned as follows: about 25% for pure research activities and about 10% for so-called related scientific activities. This makes 35% which the universities automatically set aside for research, compared to 65% for educational expenses. These figures have been verified several times in an inventory which we take every two years. They are therefore based on a statistical observation, and not on an estimate.

In addition, the government put 10% of the university budget into a national scientific research fund, which sponsors basic research projects in the universities.

Senator Bourget: Do you send a number of your students, who want to go into research, to study in universities in France, Germany, England, or the United States?

Dr. Spaey: Yes.

Senator Bourget: Do many of these young students who are interested in devoting themselves to research take advantage of the opportunities offered by the university in this area?

Dr. Spaey: Yes, but the universities do not offer these scholarships; they are either foreign or national scholarships, which allow these students to pursue their studies in Belgian or foreign universities. But for various reasons, there is as yet no general trend of emigration.

Senator Bourget: You are lucky; I hope it stays that way.

Senator Desruisseaux: Dr. Spaey, regarding the recommendations you make on the grants to be offered, are they always followed by the ministries? Do you have many administrative difficulties?

Dr. Spaey: I can say that up to the present, the recommendations have usually been followed. The government has only rarely disregarded the recommendations made with regard to budget allowances, provided these recommendations were well justified. But I should add for honesty's sake that this is not due simply to the fact that the government wanted to follow the Council's advice; it is also due to the fact that its members, particularly the Chairman and "secretary" general, have the opportunity to explain matters to the government *privatim*.

The basic purpose behind any activity of a college is to represent a general opinion, a consensus, the *vox populi*. But we must not conclude from this that a college may make the final decision, since a college must necessarily compromise.

In a college which has its own staff, this staff tries to determine in advance what compromise the college will have to make. In order to make the right decision, senator, there must be an element of dialectic. If there is only the administration and no parliament, there can be no dialogue, and therefore no exchange of questions and answers. If there is only parliament, we are under the rule of the assembly, of which each member finds himself caught up in the most complicated situations.

Senator Desruisseaux: If I may change the subject, is part of the budget reserved for nuclear research, national defence and other government projects?

Dr. Spaey: Circumstances have led us to maintain a classification system which has all the advantages and disadvantages of any classification system.

We divide our budget into five categories: the first is the university budget; the second is the budget for what we call parallel financing, that is, additional financing of basic

research. The third category is the budget for industrial and farm research. The fourth is the budget for public service and government-directed research. The fifth is for international co-operation.

Within this budget we also have what we call subject categories—such as that of nuclear or space research, and other and often important issues—but we divide the budget into subject categories only when the government has to resolve a specific problem. If, for example, the government must decide whether to participate in the construction of a standard reactor in co-operation with other countries, it requests the administration to estimate future expenses and asks whether this budget is compatible with available resources, taking into account the necessary expenses in other areas.

Senator Desruisseaux: Generally speaking, have you achieved the results you had expected from this agency when it was set up in 1960?

Dr. Spaey: The answer is yes, but with two qualifications: the first is that it is a very complicated undertaking, because the scientific world is a complicated world, and administration also poses problems. Consequently, it has taken a good deal of effort and great patience, which at times have not been easy to maintain.

Secondly, I think that, because of circumtances and difficulties which you most likely will not encounter, because you are probably better disciplined than we are, we have had to spend a great deal of time organizing. This has kept us from carrying out work which I hope we shall now be able to begin. Indeed, it is not enough to organize past and present efforts; we must prepare for the future by devising concrete programs.

Senator Desruisseaux: Is the system you adopted comparable to those used by neighbouring countries on the European continent? Are you satisfied with its progress and results to the point where you feel you can compare favourably with the countries around you?

Dr. Spaey: Once again, honourable senators, I must qualify my answer. With respect to organization, that is, co-ordination, my answer is clearly in the affirmative, because the fact that we have a centralized system means that in international conferences Belgium is always represented by the same individuals, who always support the same points of view. In this respect our system is obviously an efficient one. But I could not be as confident about the development of resources.

My country is obviously not in a position to spend immoderately; it has many problems to solve and, since it is a small country and in the scientific field we must keep abreast of all developments, the overall costs of science in Belgium are relatively high compared to Germany or France. Thus from that point of view I must say that I am not as satisfied with the results. But if tomorrow I were told that the science budget was suddenly going to be increased by five hundred million, I think I would advise my government against this move, because it is extremely risky to increase any grants too rapidly. If a married couple are given a twenty-five percent increase in income over a year, they buy a better car and a colour television, and they vacation in Switzerland—it's a well-known fact.

Senator Desruisseaux: It is human nature.

Dr. Spaey: Yes, it is human nature.

Senator Bourget: Who make up the staff of your national research council? Do these people work full time, and on what basis are they hired? How is the council actually organized? How does it work?

Dr. Spaey: The Council itself is composed of two parts: one part comprises the representatives of universities and research; that is, the "scientific" world; the other half is made up of people from economic and social spheres.

Senator Bourget: Who appoints them?

Dr. Spaey: The King.

The Chairman: Is there a federal employee among its members?

Dr. Spaey: There is no member from the Civil Service.

The Chairman: When you say "the King," do you mean the government?

Dr. Spaey: Yes, of course, the government; that is, the minister responsible—the Prime Minister.

The Chairman: You have just pointed out one difference between our systems; you have

no members representing the Civil Service in your council, while we do.

Dr. Spaey: Exception is made for the Secretary-General of National Education and for the Secretary-General of Economic Affairs who are the two high officials who can participate in the Council's work. However, the understanding is that the Council may hear those persons it considers useful for its purposes.

Senator Bourget: Are there many members on this Council?

Dr. Spaey: Thirty-four.

Senator Bourget: If half are university professors, who makes up the other half?

Dr. Spaey: Financial and social concerns, including unions.

Senator Bourget: What is the remaining full-time staff?

Dr. Spaey: The technical administration side, the working staff, including chauffeurs and typists, numbers about sixty. We have an annual financial budget of approximately twenty million francs which is equal to $400,000.

Senator Bourget: There are undoubtedly international companies with subsidiaries in Belgium. Are these companies eligible for financial aid from the government and if so what conditions are attached to such assistance?

Dr. Spaey: Your first statement is correct. There are several such firms. Their presence in Belgium answers our need for industrial modernization. As for the question of whether they can receive government assistance, the answer is yes, because a firm which settles in Belgium is necessarily under Belgian law.

Senator Bourget: Will you explain this Belgian law? For example are the majority of undertakings controlled by the subsidiaries?

Dr. Spaey: No, but there is a compulsory Belgian participation. Secondly, they must take on Belgian status and must respect the laws and legislation governing the establishment of an industrial enterprise. However because of this they can benefit from government assistance in the same way as other firms.

Senator Bourget: Are there special regulations they must follow?

Dr. Spaey: The same regulations as Belgian firms.

Senator Bourget: The reason I ask this question is to learn whether the Belgian government wants to keep for the Belgians the results of research undertaken with Belgian government assistance.

Dr. Spaey: Well I think that I can say that the Belgian government treats foreign firms in neither a better nor a worse fashion than it does Belgian firms. However, your question does underline a real problem, because we learned that one of the side-effects of the system, which is presently being changed, was that the subsidiaries were only a part of the parent company's production, and consequently often undertook no research work, and this is a serious situation in modernization. However, at the time we had no other choice. It must be added that the Government, as the only competent administrator in matters of this type, was in the dark on the problem. We are increasingly setting as a condition that the firm which is establishing itself must also set up its research services, even if at first these research services are staffed only by foreigners. In any case, this situation changes over the years because in the long run it is cheaper to employ Belgian scientific personnel, who are on the whole of good standing, than to bring in American research personnel. It would cost more to bring them across the Atlantic to live in Belgium with their families on American standards.

Senator Bourget: Thank you very much.

[*English*]

The Chairman: Senator Grosart

Senator Grosart: My question, Dr. Spaey, if I may put it in English, concerns your Minister of Science Policy. I believe that is the title you give him. I understood you to say he has no budget of his own. Is that correct?

Dr. Spaey: Yes.

Senator Grosart: Who then decides the allocation of the 10 million francs that go to industry for research development? Or put it this way: what is his function in the decision?

Dr. Spaey: It is the Cabinet, or as you would call it here the Privy Council, that makes decisions about the total budget and allocation of resources for each part of the budget and, as sometimes occurs, for special

actions. The minister does not himself use the funds. Each minister receives his share in the framework of the decision of the Government as a whole, and the Prime Minister, or the Minister délégué, is the chairman of the committee. It is he who proposes the figures of the budget before the year in which they will be expended. For example, we are now deciding in 1968 what budget we will have in 1969. Then after that each minister may use these funds in his own budget, but in each budget of the various departments there is a special section for scientific activities, and it is the totality of all these sections together that forms the budget for science.

Senator Grosart: What then is the function of the Science Minister?

Dr. Spaey: Well, there is really no Science Minister.

Senator Grosart: Well, the Science Policy Minister.

[*Translation*]

Dr. Spaey: I do not see that there is any problem here but perhaps you could be more specific with your question. There is no single minister of science but rather there are several. All ministers have their own scientific designation. Why? Because we feel that science is the razor's edge, and if we deprive each minister of his scientific endeavours we would be taking from him an important factor for development and motivation. However, as all these activities are working towards the economic progress of the nation, all encompassing choices must be made from the whole system. For this reason we have a prime inister who is responsible for them, or else a minister representing scientific policy. Strange as it may seem, this man is very busy. This is very much to his own surprise as he did not expect to have all sorts of complicated problems to solve, problems which no other minister is capable of resolving because he does not have all the available information.

[*English*]

Senator Grosart: How would his function differ from that of the British Minister of Technology?

Dr. Spaey: It differs in that the British Minister of Technology is responsable only for part of the science policy, namely, that of the industrial technology, and he has a budget for that. On the other hand, the Minister of science Policy in Belgium is responsible for all problems related to science and higher education, but only in respect of the great orientations and decisions.

Senator Grosart: I understood you to say that the total budget in the Industrial sector was about 1 per cent of G.N.P.

Dr. Spaey: Yes, from the public and private budget. The two together amount to 1 per cent of the G.N.P.

Senator Grosart: Does that include the five categories?

Dr. Spaey: No, it includes only research devoted to industry and agriculture.

Senator Grosart: What then would be the total percentage of G.N.P. of all Government departments?

Dr. Spaey: I think it would be more or less one three or one four, the same as you have now.

Senator Grosart: What major European nations have a science minister or a science ministry?

Dr. Spaey: France, Germany and Belgium.

Senator Grosart: Does Italy?

Dr. Spaey: Italy? It is approximative.

Senator Grosart: Spain?

Dr. Spaey: Spain, no.

The Chairman: Does Sweden have a science ministry?

Dr. Spaey: In Sweden I think it is the Prime Minister who acts in that capacity.

Senator Grosart: That is all, thank you.

[*Translation*]

Senator Desruisseaux: In your relations with industries, Doctor Spaey, can you complain for instance about political pressures which could hinder a program?

Dr. Spaey: Are you referring to political pressures?

Senator Desruisseaux: To receive subsidies or to obtain the assistance needed for research in some fields?

Dr. Spaey: The answer is yes, senator. However, I believe that in a democracy these pressures show up in all fields and are at the same time a good and an evil. Nevertheless,

we resist unfair pressures as much as possible.

Senator Desruisseaux: One more question, please.

The Chairman: It will have to be the final one as Dr. Spaey is already late.

Senator Desruisseaux: I only had two and I think he can answer briefly. I will ask them briefly. Does the recent situation in the Common Market affect your particular field of endeavour?

Dr. Spaey: Yes, and in this respect the problem of the Common Market is rather complicated. You know that the Common Market was created about ten years ago by the Treaty of Rome, if my memory serves me well, with a double objective in mind: first to create an open market and then to bring about a political union.

Senator Desruisseaux: Yes.

Dr. Spaey: The second objective was thwarted by various political circumstances and the first objective, an open market, is now coming into being. However, at that time we did not realize that an open market alone is not enough to automatically ensure economic progress.

The American market is characterized not only by its size but also by the whole organization or industrial structure. The whole public organization is set up for this wide market and within its scope. In comparison we can say that the European market is without a doubt equivalent in size to that of the United States. It is one in which industries are set up on a national basis, and the objectives, both national and public, which are extremely vital to American industry, are also at a national level. This is a serious handicap. European countries, Belgium in particular, have already put forth considerable efforts to arrange for an economic policy in conjunction with the Common Market. Within this economic policy foresee an important place for research and development in what we know as large-scale technology. We realize that in fields such as space, nuclear research and computer technology, essentially, and in the transportation field, the economic effects can be especially important. In fact, they are sectors which touch on all branches of advanced technology and which require the breadth of an industry or at least of a large business or syndicate. Finally in these sectors there is of course a need for the support of public interests and consequently for the certainty of agreements between the European nations.

We believe that from the trends of modern and future society's demands, it is a mechanism which will stimulate economic and political integration which up until now political law and hopes have failed to do. However you know as well as I do that there are obstacles and we must wait patiently and steadfastly for them to change.

Senator Desruisseaux: Thank you.

The Chairman: Dr. Spaey I realize that you are already late but I should like to ask a final question. Could you describe as briefly as possible the efforts you are making in the field of human sciences, the social sciences?

Dr. Spaey: Mr. Chairman, we are concerned with the development of the social sciences as is the case in many countries. We believe that in future societies the social sciences in conjunction with the human sciences in general will play a role as important as the pure sciences. The use of scientific methods and their adaption to the needs of mankind are going to create extremely complicated problems. However, we see that in Europe, and in Belgium as well, the social and human sciences have not evolved as quickly as in the United States. This imbalance occurs because for too long we concentrated on economic and social doctrines based on mathematical models and paid less attention to the study of economic and social realities. It is something which definitely must be developed in coming years. There is a trend in this respect but as we are caught up in a swift current of all types of problems it is very difficult to have politicians consider this problem. At the same time they must be made to understand the need for the development of the natural and technological sciences and they must as well comprehend the need for developing methods of using them within a more human perspective. It happens that there are too few politicians with adequate scientific and mathematical backgrounds so as to understand the question at hand. Perhaps it is here, as well as in the universities and high schools, that everyone including jurists, should be taught the basic elements of biology and a little more applied mathematics.

The Chairman: Doctor, I realize that you are already 15 to 20 minutes late for your next appointment and that you have a plane to catch this evening. However, I should not want you to leave without expressing the committee's sincere gratitude for having so graciously accepted our invitation and for having let us share your vast experience in a field which interests us all. Thank you again. I hope you have a safe flight home.

Dr. Spaey: Thank you. I would like to say that I rarely have occasion to answer as pertinent questions from an assembly such as this.

[*English*]

Senator Grosart: Mr. Chairman, before you conclude the meeting I should like to pay a special tribute to the translator for simultaneousness and clarity. I have not heard anything to compare with it in Europe or in the United Nations. I feel that if I had a few more sessions of Dr. Spaey's eloquent French going in my right ear and this clarity of English into my left ear, I might in time become even as bilingual as you are.

The Committee adjourned.

First Session—Twenty-eighth Parliament

1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
SPECIAL COMMITTEE
ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*
The Honourable DONALD CAMERON, *Vice-Chairman*

No. 3

WEDNESDAY, OCTOBER 23rd, 1968

WITNESSES:

NATIONAL RESEARCH COUNCIL: Dr. William George Schneider, President; Dr. Kenneth Franklin Tupper, Vice-President (Scientific); Professor Louis-Philippe Bonneau, Member, Vice-Rector of Laval University; Dr. William H. Gauvin, Member, Manager, Noranda Research Centre at Pointe Claire, Quebec and Dr. A. Brewer Hunt, Member.

APPENDICES:

1. — Guidelines for submission of briefs to the Special Committee on Science Policy.
2. — Brief submitted by the National Research Council.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29009—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Philipps (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDER OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentionned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, paper and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

29009—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourabe Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—
Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

WEDNESDAY, October 23, 1968

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lang, Leonard, MacKenzie, Robichaud, Sullivan and Yuzyk—14.

Present but not of the Committee: The Honourable Senators Carter, Connolly (*Ottawa-West*) and McGrand—3.

In attendance:

Philip Pocock, Director of Research (Physical Science)
Gilles Paquet, Director of Research (Human Science)

The following witnesses were heard:

NATIONAL RESEARCH COUNCIL
Dr. William George Schneider, President;
Dr. Kenneth Franklin Tupper, Vice-President (Scientific);
Professor Louis-Philippe Bonneau, Member,
Vice-Rector of Laval University;
Dr. William H. Gauvin, Member,
Manager, Noranda Research Centre at Pointe Claire, Québec;
Dr. A. Brewer Hunt, Member.

(*A curriculum vitae of each witness follows these Minutes*)
At 12.45 p.m. the Committee adjourned until 3.30 p.m. this day.

AFTERNOON SITTING

The Committee resumed at 3.30 p.m., the Chairman, Senator Lamontagne, presiding.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Grosart, Hays, Kinnear, Lang, MacKenzie, Robichaud, Sullivan and Yuzyk—12.

Present but not of the Committee: The Honourable Senator Giguère—1.

In attendance: Philip Pocock, Director of Research (Physical Science).

The witnesses were further questioned.

The following are printed as appendices:

1. Guidelines for submission to the Special Committee on Science Policy.
2. Brief submitted by the National Research Council.

At 5.45 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE OF THE WITNESSES

Schneider, William George, B.Sc., M. Sc., Ph.D., D.Sc., LL.D., F.R.S.C., F.R.S. Dr. Schneider was born in Wolseley, Saskatchewan in 1915. He received the B.Sc. in 1937 and the M.Sc. in 1939 from the University of Saskatchewan and the Ph.D. in 1941 in Physical Chemistry from McGill University. From 1941 to 1943, Dr. Schneider was a Research Associate at Harvard University on a Royal Society of Canada Fellowship. During the next three years he was a Research Physicist at the Oceanographic Institute at Woods Hole, Massachusetts, conducting research on the properties of underwater explosions and development of anti-submarine weapons. In 1946 he joined the staff of the National Research Council as Head of the General Physical Chemistry Section of the Division of Chemistry. During 1952-53 he was on leave of absence at Cambridge University where he worked in the theoretical chemistry laboratory with Sir John Lennard-Jones. Dr. Schneider was Director of the Division of Pure Chemistry from 1963 to 1966, and Vice-President (Scientific) of the National Research Council from 1965 until his appointment as President on 1 September 1967. He is a Fellow of the Royal Society of London, The Royal Society of Canada, and the Chemical Institute of Canada. He has been awarded the Chemical Institute of Canada Medal. The Honorary Doctor of Science degree has been conferred on him by York University, and the Honorary Doctor of Laws by the University of Alberta, and Laurentian University. He is a member of The Faraday Society, the American Chemical Society and the American Physical Society, and is a member of the Editorial Board of various scientific journals. Dr. Schneider has published 120 scientific papers and is co-author of the book 'High Resolution Nuclear Magnetic Resonance' by Pople, Schneider and Bernstein. Dr. Schneider has won international recognition for his contributions to the study of intermolecular forces and molecular properties. His work in high resolution proton magnetic resonance has resulted in a number of important contributions to structural chemistry, proton exchange behaviour and hydrogen bonding. He is also noted for his extensive studies of organic crystal semi-conductors.

TUPPER, Kenneth Franklin, O.B.E., B.A.Sc., S.M., D.Sc., LL.D., M.E.I.C. (Hon.), F.R.Ae.S. Dr. Tupper was born in Lynn, Massachusetts, in 1905. He obtained the B.A.Sc. degree in Mechanical Engineering from the University of Toronto in 1929. The same year he joined the National Research Council as a research engineer, employed in the design of wind tunnels and aeronautical research facilities. From 1944 to 1946 he was Chief Engineer at Turbo Research Limited, a crown company engaged in design and development of aircraft gas turbines. Dr. Tupper was then named Assistant Director of Research and subsequently Director of the Engineering Division at NRC's Atomic Energy Project (now Atomic Energy of Canada Limited). In 1949 he returned to the University of Toronto as Dean of Applied Science and Engineering. From 1954 until 1963 he was President of the consulting engineering firm of Ewbank, Tupper and Associates Limited, Toronto. Dr. Tupper was appointed Vice-President (Scientific) of the National Research Council of Canada on 1 January 1964.

He holds an S.M. degree in Aeronautical Engineering from the University of Michigan, honorary D.Sc. degrees from Laval University, the University of Western Ontario and the University of Sherbrooke, and the honorary LL.D. degree from McMaster University. Dr. Tupper is an Honorary Member and Past President of the Engineering Institute of Canada, Vice-Chairman of the Board of Governors of the Ontario Research Foundation, and a Fellow of the Royal Aeronautical Society.

BONNEAU, Louis-Phillipe, B.A.Sc. Prof. Bonneau was born in St. François, County of Montmagny, Quebec, in 1916. He received the B.A.Sc. with Honors (Summa Cum Laude) from Laval University in 1942. From 1942 to 1946 he was an Engineer with Canadian Johns-Manville, Asbestos, Quebec. He joined Laval University in 1947, and was a Professor in the Department of Mechanical Engineering until 1954, when he was appointed Director of that Department. Prof. Bonneau was appointed Vice-Dean, Faculty of Science, in 1956, and Dean, in 1960. In 1961 he was appointed Vice-Rector of Laval University. The Honorary Doctor of Science degree has been conferred on him by Queen's University and Laurentian University. He was named a member of the National Research Council in 1963, and is a member of the Board of Directors of Laval Hospital, and of the Board of Governors, Canadian Bankers Institute. He is a member of the Engineering Institute of Canada; Corporation of Professional Engineers of Quebec; Association Canadienne-Française pour l'Avancement des Sciences; Canadian Institute of Mining and Metallurgy; American Society for Metals; American Society of Mechanical Engineers; and the American Society for Heating and Refrigeration Engineers. He is a former member of the Defence Research Board, and the Committee of Science and Medicine for the Canadian World Exhibition, 1967.

GAUVIN, William H., B. Eng., M. Eng., Ph. D., D. Eng., F.C.I.C., P. Eng. Dr. Gauvin was born in Paris, France, in 1913. He received his early education in England, Belgium and France, and came to Canada in 1930 where he worked as a chemist for the next eight years. From 1938 to 1944 he attended McGill University, obtaining the B. Eng. in 1941 and M. Eng. in 1942. From 1942 to 1946 he lectured in the Chemical Engineering Department at McGill University, and obtained the Ph.D. there in 1944. From 1944 to 1946 he was Plant Superintendent with F. W. Horner Limited, Montreal, and the following year returned to McGill University as Associate Professor in the Department of Chemical Engineering. From 1951 to 1958 Dr. Gauvin served as consultant to the Pulp and Paper Research Institute of Canada. In 1958 he became head of the Chemical Engineering Division of the Institute, while teaching and directing research in the Chemical Engineering Department at McGill University. He joined the Noranda Group of Companies as Manager of the Noranda Research Centre at Pointe Claire, Quebec, in 1961, and continued to direct postgraduate research work at McGill University. Dr. Gauvin is a Fellow of the Chemical Institute of Canada, a past Member of the Council of the Engineering Institute of Canada, a Member of the American Institute of Chemical Engineers, the Institution of Chemical Engineers, the American Institute of Mining and Metallurgy, the Canadian Institute of Mining and Metallurgy, the Canadian Pulp and Paper

Association, the Association of the Pulp and Paper Industry, the American Society for Engineering Education, and the Corporation of Professional Engineers of the Province of Quebec. In 1964 he was named a member of the National Research Council of Canada. Dr. Gauvin has published over seventy-five papers in the fields of electrochemistry, heat transfers, and particulate systems (technology of droplets and small particles) and has patents on a new chemical engineering processing technique (the Atomized Suspension Technique).

HUNT, A. Brewer, B.A. Sc., D. Eng., F.E.I.C., F.I.E.E.E. Dr. Hunt was born in London, Ontario, in 1902. He graduated from the University of Toronto in 1928 with the degree of Bachelor of Applied Science, and received the medal award from the British Association for the Advancement of Science. Immediately following graduation, Dr. Hunt joined the Northern Electric Company as a manufacturing methods engineer. He held many senior engineering and management positions with the Company and, from 1960 until his retirement in 1967, held the position of Vice-President, Research and Development, in charge of the Company's laboratories in Ottawa. Dr. Hunt was awarded the Engineering Institute's Ross Memorial Medal, in 1946, for his paper entitled "The Future of Radio Communications in Canada." In 1954 he was loaned to the Government for a period of eighteen months as Director of the Electronics Branch of the Department of Defence Production. In 1966, Dr. Hunt was named a member of the National Research Council of Canada. He is retired Commanding Officer of the 11th Signals Regiment (Reserve); a Past President, Director, and Chairman of the Research Committee of Electronic Industries Association of Canada; past Vice-President, Research and Development Division of the American Management Association; a member of the Industrial Research Committee of the Ontario Economic Council; a member of the Research and Development Committee of the Canadian Manufacturers' Association; and a member of the advisory boards of the Faculty of Science of the University of Ottawa, the College of Engineering of Saskatchewan University, and the Materials Research Unit of McMaster University. He is a member of the Association of Professional Engineers of Ontario, the Institute of Electrical and Electronic Engineers, the American Association for the Advancement of Science, and a Fellow of the Engineering Institute of Canada.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, October 23, 1968.

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, when on March 12 this year our committee held its first public hearing, I explained that our inquiry would be divided into three main phases. Up until now we have heard experts on broad questions of science policy both from Canada and abroad. Today we are beginning the second stage which will consist of hearing the research agencies of the Canadian Government, and finally when we are through with this second stage, as we have agreed previously, we intend to receive representations from the provincial research agencies, and from the private sector including universities, industry and professional organizations.

On behalf of the members of the committee, it is a great pleasure for me to welcome the President of the National Research Council and his colleagues and associates who are at this table, Dr. Schneider, President; Dr. Tupper, Vice-President (Scientific); and then Dr. Hunt on my far right.

[*Translation*]

On my left, you see professor Bonneau, Vice-Rector of Laval University, and, finally, Dr. Gauvin, also a member of the National Research Council.

[*English*]

The National Research Council is one of the oldest and still, I believe, the most important government research agency. It is therefore quite appropriate that we begin this second phase of our inquiry with this institution which has contributed so much to Canadian scientific effort. So, without any further introduction, I would ask Dr. Schneider to make his statement, and then of course we will go on to the question and discussion period as usual.

Dr. William George Schneider (President, National Research Council): Mr. Chairman, honourable senators, first of all I would like to say that we appreciate very much this opportunity to appear before your committee on Science Policy. Since the National Research Council has a total day-to-day involvement in science, your study will certainly be of very special interest and importance to us.

We have prepared a formal submission along the lines suggested to us by your research staff. This, together with a lot of additional documentation, which we have provided, will make rather a lot of reading.

Accordingly, we thought it might be useful to supplement this with a short brief which reviews our current situation in science and outlines a number of issues and problems which we feel must be dealt with by future policy.

In order to set some of these issues in perspective, I would like to begin with a few general remarks about science and public policy.

I. SCIENCE AND PUBLIC POLICY:

The principle of a public and government responsibility for science is now generally accepted in all advanced countries. This has come about not so much because science itself represents a primary mission of government, but because science and technology provide an essential means of achieving national goals. But to utilize and exploit science effectively to this end requires a vital and highly competent indigenous science. Accordingly, when we consider what is generally referred to as science policy, there are really two main aspects: (a) policy for science proper, which is concerned with developing and maintaining in a favourable atmosphere a strong

indigenous science, and (b) policies concerned with the mobilization and application of scientific resources toward achieving national goals. These two aspects are related since a weak and incompetent science is not likely to achieve the hoped for results even with large expenditures of public funds.

Decision-making and policy formulation in matters relating to science must take account of certain criteria (criteria of choice) as well as specific goals and objectives. The values and benefits of scientific research may be classified according to intrinsic scientific criteria, and/or according to social, economic and technological criteria. The scientific criteria, whether it is good or bad science, are relevant both to basic science and applied science. While the objectives and subject matter may vary, the discipline and methods of science, and the techniques of science are common elements. Because of their specialized nature, the purely scientific criteria must be established and applied by knowledgeable scientists. On the other hand, the social economic and technological criteria can only be assessed in terms of defined goals and objectives formulated by public policies. Scientific research can then be assessed in terms of its potential and effectiveness (by comparison with alternative approaches) toward furthering these objectives.

The two aspects in the total government responsibility for science, which, although interrelated and interdependent, require basically different decision-making and policy formulation as follows:

a) Science as an Essential National Activity of its Own:

We include here all those activities necessary for the development of our scientific resources and maintaining a strong indigenous science. These are for example, basic research (which includes almost all university research), research manpower training, research facilities, scientific publications and scientific information systems, scientific organizations, research services, etc. In addition to its cultural and educational values, science is a national investment, and constitutes a creative and progressive element in advanced societies. Science has its own standards, which, though world-wide in their effects, largely originate in scientifically developed countries. Yet no country has a monopoly on ideas, and good ideas come from highly competent individuals working in a favourable and stimulating environment. (This point needs stressing when we speak of scientific resources). Moreover, because of the unpredictability of scientific discovery, new scientific advances cannot be planned or centrally directed. Planning and decision-making of this kind of science, at the government level, should be primarily confined to the establishment of the appropriate scale of overall funding and provision for major research facilities.

b) Science as a Contributing Component Toward Social, Economic and Technological Goals:

By contrast, science deployed in support of social, economic and technological goals can be evaluated in terms of its promise in furthering these goals, and can be planned in more detail. Resource allocation to individual programs is then guided by public policy and national priorities which must first be established. The extent to which the latter are clearly delineated will have a bearing on the efficiency and effectiveness with which scientific resources are utilized. Nevertheless, decision-making is this area is generally confronted with difficult choices between competing programs requiring detailed study and evaluation in terms of the criteria of choice referred to earlier. Thus, while scientists have an important input in terms of the appraisal, planning and implementation of individual programs, ultimate decision-making is the responsibility of government. This point is illustrated for example by the new NRC low-speed wind tunnel, by the new program of water resources research assigned to the Department of Energy, Mines and Resources, and by recent action with respect to a communications satellite.

In an operational sense, the National Research Council has been given a broad responsibility to develop and nurture a scientific research capability in Canada and to deploy scientific research for national needs. It should be noted here the latter function is also shared (in a defined way) by a number of government departments and agencies which undertake scientific research to support their particular mission.

Thus, as far as statutory functions and programs are concerned, the operations of the National Research Council fall under both policy aspects (a) and (b) above, whereas the

research operations of other agencies and mission-oriented departments fall predominantly under (b). Accordingly, because of the wider responsibilities of the Council, it must be responsive to new opportunities and new research needs which do not fall within the prescribed missions of government departments and other agencies.

As an aside, I would like to comment at this point on statements sometimes made that there is very little co-ordination as far as federal government in-house research programs are concerned. There is in fact close liaison and frequent informal consultation to avoid unnecessary overlap and duplication of research activities at the Deputy Minister level and at the working level. There exists also a number of inter-departmental and inter-agency policy and research co-ordinating committees. The Council has also set up a number of joint committees with other departments and agencies and to a large extent this function is also served by N.R.C. Associate Committees.

II. REVIEW OF THE CURRENT STATE OF SCIENCE IN CANADA:

During the two decades following World II, there has been an accelerating development of science in Canada. The initial stimulus was provided by the war itself. The research activities of NRC laboratories were expanded considerably during the war years and during the immediate post-war period. Out of these activities also grew the Defence Research Board, Atomic Energy of Canada Limited, and later Canadian Patents and Development Limited, and the Medical Research Council. This period also saw an intensification of research activities in a number of government departments concerned with natural resource development.

In 1946, there were really only two universities in Canada in a position to grant doctorate degrees in most scientific disciplines. The rapid expansion of our universities, and of our educational system generally during the post-war period has been a remarkable Canadian achievement. Today at least fifteen universities have strong graduate schools in science and engineering, and another dozen or so award advanced degrees in a number of scientific disciplines. The National Research Council's contribution to the expansion of university research activities and graduate training has grown from 7.2 millions in 1960-61 to 45.8 millions in 1967-68.

New research personnel required to achieve these periods of expansion, first in government laboratories and later in universities, were supplemented in large measure by immigration and recruitment abroad. The output of new graduates from Canadian universities continued to be well short of the needed research manpower. Although there has been some loss of Canadian graduates through emigration, their number has been substantially less than the number of new scientists and engineers gained by immigration.

As mentioned earlier, a number of universities have built up strong graduate schools, and several of these are approaching frontline rank comparable to the best anywhere. In general, the older disciplines, such as mathematics, physics, chemistry, biology and geology, tend to be more highly developed and now have a considerable number of investigators of international stature. We have not won Nobel prizes in recent years (if this is an indicator), but we now have some runners-up, and in five or ten years Canada should be able to gain its proportionate share. Nevertheless, a number of branches of the main disciplines are still weak and need strengthening, as for example, molecular biology, inorganic chemistry, theoretical physics and chemistry, solid state physics, and biophysics. Some very promising research groups are developing in the newer fields of space sciences, radio astronomy and in computer sciences. Generally speaking, the applied sciences and engineering disciplines are as yet not as highly developed as the pure science disciplines. This is largely attributable to the fact that research in engineering schools is expensive, cannot flourish without a favourable industrial climate, and has had a much later start, although it is now developing rapidly. Scientific research in the francophone universities also had a later start, and until recently, tended to have a slower growth rate than that of the larger anglophone universities.

During the past decade in which there has been a rapid expansion of scientific research in universities, industrial research has had a very modest growth. The reasons for the rela-

tively disproportionate development of scientific research and advanced technology in Canadian industry are many, and cannot be detailed here. They bear a close relationship to the general Canadian industrial climate, including such factors as size of markets, tariffs, transportation costs, subsidiaries of foreign companies, and in particular the absence of extensive government military and space programs. It also must be admitted that in the face of a rapid university expansion in the recent past, industrial laboratories have not competed successfully for their share of top scientific and engineering talent. It is sometimes claimed that to-day's graduate is too strongly academically oriented and not interested in industrial research, and those that are, frequently look to industries in the United States in the belief that industrial research opportunities are lacking in Canada. Some of these difficulties could be overcome by a greater strengthening of the ties between Canadian industry and the engineering schools.

Our competitive position in world markets and our industrial and economic expansion in Canada will depend to an increasing degree on advanced technology. Presently, there exists a number of programs, including those of the National Research Council and the Department of Industry, which are intended to promote and assist industrial research and development. The results from these programs have been encouraging, but they are as yet modest programs and fall far short of what is needed. Some well planned and integrated programs are necessary to generate the momentum needed in this area.

While we have had a continuing shortage of highly trained research manpower in the past, according to the most recent study now being completed by the Council, this picture is likely to change rapidly because of the expansion of our universities and particularly university graduate training in recent years.

Chart I displays the number of new Ph. D. graduates in science and engineering in each year during the period from 1959 to 1968 and projected to 1973. In this study, Ph. D. graduates were used since there is a correlation between research activity and manpower trained to this level. In round figures the annual output of new Ph. D.'s has increased from over 200 in 1959 to a projection of around 2,000 per year in 1973. (These figures do not include Ph. D.'s in the Medical Sciences). The annual number of new employment positions has increased from somewhat over 400 to nearly 1,000 and is not expected to increase greatly beyond this figure. While these projections are subject to limitations and uncertainties, it does appear that we will no longer be faced with an overall deficit in scientific manpower.

The second feature displayed by Chart I is the distribution by sector, of the new employment positions. The rapid rise in Ph. D. employment over the last 10 years is directly related to the rapid university expansion and the universities themselves have been taking up most of the new graduates. In the future, while the rate of university expansion is expected to be more modest, the universities are likely to continue to employ the largest number of new graduates, with government employing slightly increasing numbers, and there does not appear to be an increasing demand likely to be forthcoming from the industrial sector, under present conditions. This general picture, however, must be strongly qualified. The figures represent an average over all disciplines and there is considerable variation among different disciplines. In many disciplines shortages may be expected to extend well into the seventies. The requirement for new employment positions is basically a projection of existing activities and programs and involves the assumption that no majór new government-sponsored programs will be launched during the next few years. With the greater availability of scientists and engineers at the Ph. D. level, it is very likely that in future an increasing number will be absorbed by technical schools, community colleges and other post-secondary institutions. Account must also be taken of the fact that the projected number of graduates include a considerable number of foreign students and the number likely to return to their country of origin is unknown.

Chart II illustrates the distribution among the three sectors of Ph. D. scientists and engineers in another form. The total average number of Ph. D.'s employed in all sectors was 4,300 for the period 1959-63 and is projected to rise to 11,500 in 1973.

Senator MacKenzie: Mr. Chairman, may I ask one question. Does that include all the Ph.D.'s or only those in science?

Dr. Schneider: Only those in science and engineering, excluding medical science. It does not include social sciences and the humanities.

Senator MacKenzie: Thank you very much.

Dr. Schneider: Subject to the qualifications indicated earlier, the university sector will take up an increasing proportion of the total Ph.D. graduates, increasing from 53% in 1960 to about 70% in 1973. The corresponding figure for government laboratories will be halved from 33% to 17%, while there will be virtually no relative change in the industrial sector. The present studies relating to scientific manpower resources are as yet preliminary and lacking in sufficient detail. However, they are the most up-to-date presently available, and have implications which should be kept in view in respect of shaping national policies and programs.

CHART I

Ph. D OUTPUT AND NEW EMPLOYMENT
CANADA 1959-1973
(scientists and engineers)

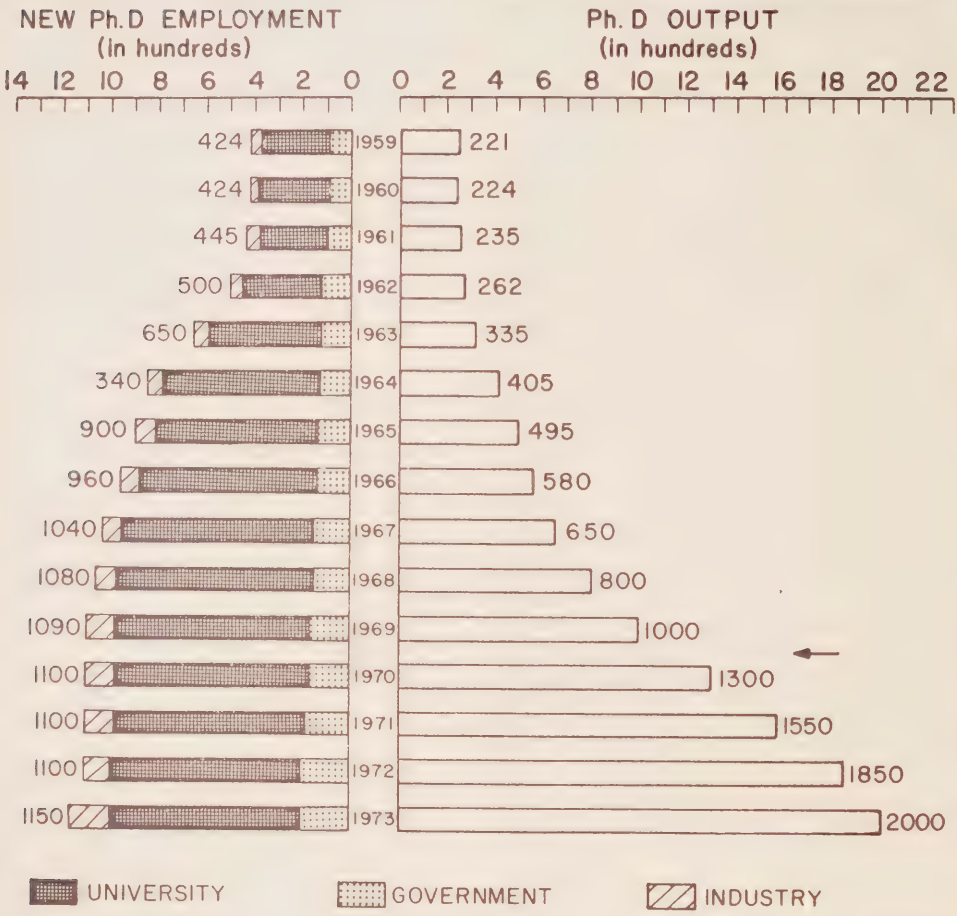
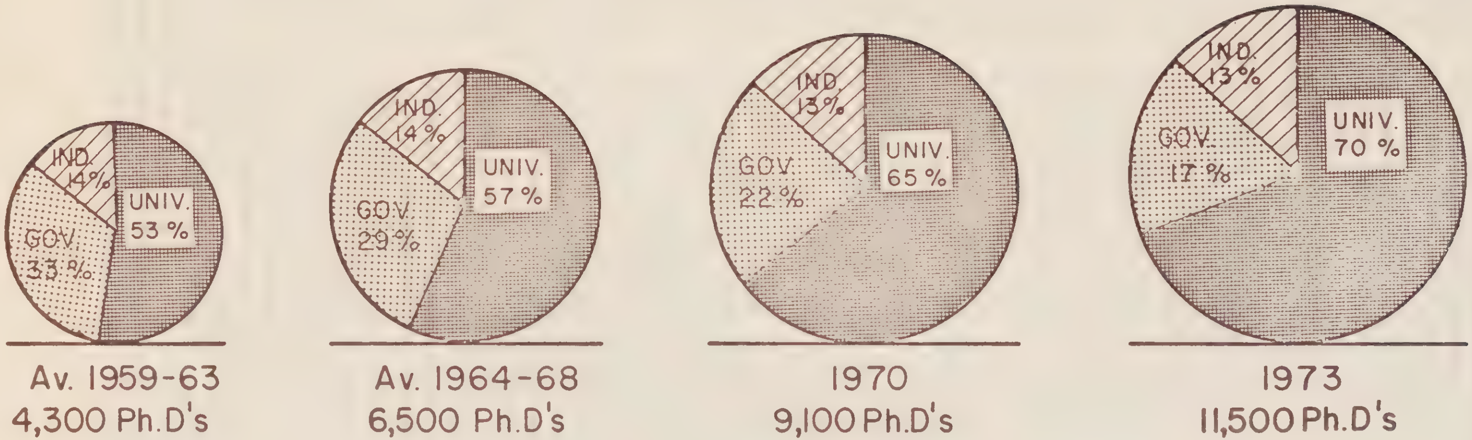


CHART 2

EMPLOYMENT OF Ph.D's
IN SCIENCE AND ENGINEERING
CANADA 1959–1973



III. CURRENT ISSUES AND PROBLEMS:

1. It is clear that while we have made great strides in our scientific development during the past two decades, our present development with respect to the application and utilization of science is alarmingly unbalanced. We have not achieved a sufficient rooting of R & D in the industrial sector, nor has existing industrial R & D developed a sufficient momentum for growth to assure the future welfare of advanced industrial technology in Canada. The reasons for this are complex and go well beyond a willingness on the part of Canadian industry to undertake a greater effort. Our present industrial climate, structure, and resources are not sufficiently favourable to induce industry to undertake major long-range R & D programs. Longer range programs to develop new advanced technology frequently require a lead time of from five to ten years and an economic return may not be realized until ten or twenty years later. Investment in industrial research must compete with other forms of investment which an industry can make. Since many industries are chronically short of capital, it becomes difficult to fund industrial research and much more difficult to do so when the economic return may not be realized until ten or twenty years later. Accordingly, our minimal industrial R & D effort has concentrated for the most part on short-range programs likely to produce a more immediate return. More often than not this is concerned with minor extension or elaboration of existing technology rather than with the development of promising and entirely new technology. Both are essential, but the latter is more likely to provide the challenging opportunities in industrial laboratories which will attract the highly gifted and creative scientists and engineers. Their presence in the industrial environment will greatly stimulate innovation generally. Our deficiencies in these respects today will increasingly compromise our economic potential ten or twenty years from now.

Research and development, although it requires the greatest lead-time, and therefore must be provided for and planned well in advance, is but one part, and usually the least expensive part, of industrial innovation and successful economic exploitation. As a nation we must make a much greater commitment to new technology. With limited resources we cannot of course hope to challenge on all fronts. But by being selective and concentrating our efforts we can become pre-eminent in those areas where we have a favourable base or special advantage. As part of Federal government policy these areas should be identified and given special support and encouragement on a priority basis. Possible areas which should be considered include transportation, telecommunications, building materials and building technology, environmental pollution, metal physics and metallurgy, marine sciences, food technology, energy and power technology, northern development and specialized computer technology.

2. In order to exploit and assimilate new scientific knowledge and technical information, and develop engineering design data, it is essential that research scientists and engineers have ready access to the rapidly expanding world-wide information pool. This means on the one hand that industry must have scientists and engineers competent to interpret and assimilate this knowledge, and secondly, a rapid system of information dissemination capable of providing them with the special knowledge they require. Through the National Science Library and Technical Information Service, the Council has attempted, during a long period of time, to provide a stockpile of scientific and technical information and a mechanism for its transfer into industry and universities. A period of transition has now been reached when new technologies—the digital computer on the one hand, and high capacity information transmission networks on the other—make it possible soon to increase greatly the extent of the services offered. In the immediate future, it seems likely that an expenditure to make existing scientific and technical information widely available will be more rewarding than an expenditure simply to gain, through research, new information. Consequently, the provision of computer and data transmission systems to the National Science Library to an increasing extent can be anticipated.

3. Science generally in Canada has now developed a reasonably broad foundation and considerable strength, though somewhat diffusely based in a considerable number of university laboratories. The most immediate needs for the future will be to develop greater depth and concentration in important selected areas. The Council's recently established program of Negotiated Development Grants is intended to aid his objective. Grants of this type have already been awarded to a number of universities in such areas as materials science, pestology, mathematics and

computer science, and mechanics. There is also a need to provide for special research facilities and to foster more inter-disciplinary research. In certain research areas stronger links and co-operation with social science disciplines must be established. Finally, if our limited scientific resources are to be developed and deployed in the the most effective manner, a much closer interaction and collaboration between university laboratories, government laboratories and industrial laboratories than now exists must be given strong encouragement. This would be greatly aided by mutual participation in large research projects of major national significance or in important local or regional problems.

4. National policy must concern itself with the application of science to social and economic problems and to improving the human environment. Generally these are areas which tend to fall outside the industrial sector. They include, for example, conservation, pollution and other environmental problems, housing and urban problems, fire protection, law enforcement, public health and public safety. The application of science to these social problems is greatly complicated by the structure of government in Canada where generally the provinces carry the responsibility in the areas where the problems lie. Federal government programs tend to be restricted to the solution only to the most basic common problems, but do not provide for the application of the solution, which has to remain with the provinces.

5. A further area of national policy requiring urgent attention is that of regional disparities. During the recent build-up of scientific research in Canadian universities, it has been particularly apparent that the resources from provincial sources available to universities in the Atlantic provinces have been considerably less than those in other provinces. This merely reflects a long-standing economic disparity in these provinces. Scientific research can contribute toward an alleviation of these problems. Particular programs should be integrated with regional programs designed to promote resource and industrial development.

6. The role that science can play with respect to problems of national unity and inter cultural relationships may be somewhat indirect, but nonetheless important. The development of science in francophone universities has had a later start due to the lack of emphasis on science in the past. There is now a serious attempt to catch up, and to do so over a shortened time-scale will require augmented resources. The establishment of some major research laboratories in which French is the working language should be an important national goal. Exchange programs for visiting professorships and students between francophone and anglophone universities should also be encouraged.

7. To an increasing degree scientific research activities are also being sponsored by provincial governments, in support of specific problems and objectives. In the majority of provinces these programs are centered in provincial Research Councils or similar bodies. Research projects are frequently also sponsored in university laboratories. Accordingly, a national science policy should take account of programs and goals of provincial governments and through mutual consultation promote co-operation and co-ordination of research programs.

8. Finally, I should like to comment on the future role of the National Research Council in the evolving national framework for science. Under its Act, the National Research Council was set up as an independent agency of the federal government with a broad responsibility for science. With the recent establishment of the Science Secretariat and the Science Council, both with strictly advisory roles, the National Research Council continues as the main operational agency in the science area. Occasionally it is suggested that some of the present functions of the Council should be separated, as for example, industrial research, or the university grants program. The setting up of a separate Engineering Research Council has also been suggested. In our view, the splitting of pure and applied science, and the separation of the above functions from the National Research Council, would be a serious mistake. The effectiveness of the Council in the past has been due in large measure to the close working contact it has established with the scientific community, both in pure and applied science, and to the confidence it has engendered by practising high quality science in its own laboratories. Were NRC to be isolated from university and industrial research activities, it would soon become ineffective as a national science body. At a time when major research projects require an interdisciplinary approach and frequently also require co-ordination of co-operative programs with university, industry and government laboratories, excessive fragmen-

tation of agencies would be a serious handicap. As a result of past efforts of the Council, strong university research centers have been developed, assuring an adequate supply of research-trained manpower for the future. University research support must continue, but we must now also greatly intensify our efforts in applied and industrial research. For this the first urgent step must be a clearer delineation of national objectives and priorities. In the meantime, the National Research Council will continue to work towards solutions in the various problem areas outlined above, consistent with its mission, and national need.

Senator Lang: Mr. Chairman, I would first thank Dr. Schneider for his care and trouble in preparing this brief. We recognize, Dr. Schneider, the importance that your agency plays in the study which we are undertaking. We realize that we must understand thoroughly the aims, objectives and methods of operation of the NRC, in order to make our study complete. Accordingly, we attach great importance to your presence here today and appreciate it.

In addition to the material furnished by the NRC, some material has been furnished to me by our committee and I realize, for the first time, the extent of the "embarrassment of riches" in Ph.D.'s which we seem to be about to enjoy in this country.

I know you will be familiar, Dr. Schneider, with some of the other material I have in front of me, which would indicate that this problem is not confined to Canada but may be a relatively widespread phenomenon in the western world—if we are to believe Dr. Ernest Rudd, who wrote an article in *Minerva* of last spring, entitled "The Rate of Economic Growth, Technology and the Ph.D."; and particularly an article in the October edition of *The Economist* entitled "How to Lose the Technological Race," which underscores the dangers inherent in this diversion of our highest talents into the pure sciences and into the academic field to the detriment of the technological side of our society.

I know very well that you have underscored this in your brief and have attempted to some extent to pose some solutions to the problem. I would like to suggest to you that in this committee we would hope that the NRC could be more specific in this area. Although you suggest that is the primary responsibility of government policy in these directives, I think that, in turn, it is the activities of the Council that will prompt those government policies. It may be that the suggestion made—which you referred to as splitting pure and applied sciences—arises from this problem. I do not know that.

In your conclusion, I note that you say that your past efforts must be continued to maintain strong university research centres and that university research support must be continued. You have mentioned that you must intensify your efforts, "our efforts," in applied or industrial research.

If this problem has a significance which I think I would have to attach to it, from the brief reading I have done, it would appear to me that it is time for the NRC to embark on very specific means of altering the direction of the educational priorities in this country in this area, and specifically, perhaps, through your control of grants to universities for research, or in stimulating activity in the industrial sector in a way far in excess of those efforts which we have tentatively seen in the Program for the Advancement of Industrial Technology (PAIT) and the other programs.

I would invite your comments on these remarks.

Dr. Schneider: Honourable senators, certainly this is an area that we are studying very seriously now and we certainly hope very soon to come up with proposals and programs which we would hope the Government would consider very favourably. This is a situation which has come upon us rather quickly. As you can see, in the past we have had this chronic shortage of research-trained manpower. We have had to recruit most of our people from abroad. Now, for the first time, we are beginning to graduate enough research-trained manpower, so that now we can really do something.

I think the problem here is to find out why things are not opening up faster in industries. We have to get more of this manpower channelled into industry working in areas of advanced technology. The problem really is to find ways and means of encouraging and promoting this objective, and this is certainly a problem we are studying very seriously.

Of course, this would also involve other Government departments. It is not an easy problem.

On the other side of the picture, I would not say, as you put it, that the present output of Ph.D. graduates is an embarrassment. On

the contrary, I think this is an opportunity. Certainly we have had too few of those people in the past. Certainly, also, a lot of those will, I think, go into the other educational fields, such as community colleges and so on, and it may be even into high schools, which might be a good thing.

Also, in the past, there really has been no competition for a position. Every graduate during the past ten years was immediately offered perhaps half a dozen jobs to choose from. There has been no competition for any of those positions. Now, for the first time, there might be some competition, which may not be a bad thing.

By and large, I hope that some of these resourceful people, well-trained, will become scientist-entrepreneurs and perhaps start up their own industries.

I certainly would not regard the number as an embarrassment.

Also, as I have pointed out, there is quite a number of foreign students in this group. I do not think we are anywhere near producing too many Canadian Ph.D.'s. Of course, in the past, we have had to rely very largely on the supply of foreign-trained scientists, through immigration and recruiting abroad. We have gained tremendously by this, and I suppose it is reasonable that we are prepared not to train some foreign students in Canadian universities.

By and large, the number of Canadian Ph.D. graduates is not an oversupply and, of course, this varies in different disciplines.

I agree with you that the NRC will certainly be taking initiatives to try to find ways and means as to how these directions I have indicated might be promoted and encouraged, and we certainly will be coming up with proposals.

Senator Lang: If I may still have your attention, Mr. Chairman, I would like to direct a few questions to Dr. Schneider, and I hope I am not labouring a point.

I would like to revert to my reference to the article in *Minerva*, written by Dr. Rudd, where it is strongly suggested that expenditures on pure science are not in the best interests of at least the economic development of any country and, in this case, he is specifically referring to Great Britain. However, I imagine this applies even more to Canada.

Dr. Rudd in his article states:

> (1) Those figures which have so far been published for the research and development expenditure of industrial countries show no relationship between the level of research and development expenditure and the rate of economic growth.
>
> (2) Discoveries in pure science do not necessarily stimulate the production of inventions . . .
>
> (3) The purchase of "knowhow" by a firm or even a country can play a more important part in technological advance than the firm's or the country's own research and development.

I suggest, Dr. Schneider, if there is any merit whatsoever in these observations, that perhaps the course the NRC has been following in connection with the expenditure of public funds on pure science, either in house research or universities, may very well have been a misapplication of funds. May I have your reaction to that?

Dr. Schneider: First of all, I think this question has been studied a great deal, as you know, by OECD—the Organization for Economic Co-operation and Development—in recent years. The difference, for example, between industrial development and industrial innovation in Europe and in the United States is that Europe did not really perform as well in the application of industrial exploitation, even though it is true there is a very competent fundamental science in Europe. Now, I believe it would be inaccurate to say that you could have a strong industrial science without also having some basic science, or what we have called a strong indigenous science. If you look at any advanced industrial country you will see that they have this. If you do not have this strong indigenous science and some good scientists who are in contact with front-line science who know what is going on elsewhere then, of course, you cannot have the other either. They would not be able to assimilate the science that is being developed elsewhere to exploit it for their own purposes. That is one side of the story. On the other side, the question of industrial innovation raises other problems. I do not feel that you can have a strong industrial country without having a strong indigenous science as well, because they go together. However, you could have a strong science without having industrial exploitation and this, of course, is what European countries, as well as Canada, are worried about. There are many other problems

here; in other words, if you simply hope to live on imported and second-hand technology, you are always going to be well behind.

I feel that you need this strong indigenous science to have a competence in front-line science, but then you have to build up the applied sceince. You have to make sure that there is sufficient communication so that the pure science backs up the applied science.

Now, for many reasons we have not sufficiently developed our applied science, particularly our industrial research, and this is a problem we have to cope with now. We must find ways and means to do something about it.

In regard to universities, you mentioned the NRC grants. As I previously mentioned, there has been a very serious shortage of research-trained manpower in Canada. I think these policies, in order to build up universities, were national as well as provincial, and they are not decisions that the NRC can necessarily make on its own. The decisions with respect to developing universities are provincial matters, and the National Research Council's role is simply to help develop the research along with the graduate training of research manpower.

Perhaps someone else would like to add something further.

[*Translation*]

Professor Louis-Philippe Bonneau, Member of the National Research Council and Vice-Rector of Laval University: Mr. Chairman, could I add a few words to what the President of the Council has just said?

Perhaps there is also in the mind of a certain number of persons a slightly false idea about the amount of money, or if you prefer subsidies, which will support this so-called pure research.

If we examine even slightly where the money is directed, we can realize that, in many cases, subsidies are really granted for so-called applied research, although the Council may have given to Ottawa a perhaps slightly false idea in this respect, because the laboratories which made the headlines are probably science laboratories where research was in this so-called pure science.

It has quite often been forgotten that an important part of the budget of the laboratories situated on the Montreal Road has played an extremely important role in the development of what is called Canadian technology. When we consider natural sciences, we must realize that the Council, even if it gave the impression that it supported pure research above all, has nonetheless given considerably to applied research. This applied especially to research in universities and more particularly to engineering. I remember that, in 1954, the President at that time had convened a meeting of deans in civil engineering, in electrical engineering and of deans of engineering schools to try and stimulate this research. This was done, and I believe that we have at present a situation where the deans of engineering schools are extremely strong in their requests. All this comes from the fact that the Council did a great deal to develop this situation.

I think this is the starting point.

The problems are whole and extremely difficult, but I believe that we should not display masochism and complain that we did not do what should have been done. I believe that this was a great effort.

Senator Connolly (Ottawa West): Have you any examples?

Professor Bonneau: Certainly. In engineering, you have, in the majority of universities, very strong schools. I am thinking in particular about such sectors as electrical engineering at the University of British Columbia, which is recognized at the international level.

Many other sectors across Canada could also be considered as very good engineering sectors. I am thinking, for instance, about Dr. Patterson's Institute of Aerospace Studies in Toronto, which is also one of the great laboratories in the international field.

Point-blank, it would be difficult for me to give you the whole series, but if a survey was made, it could be found.

[*English*]

Senator Lang: I have no intention of trying to monopolize the committee's time this morning, Mr. Chairman. I would like to direct a request to Dr. Schneider that arises out of my perusal of the Montreal *Gazette* this morning where I read an account of the exploitation by a company in Smiths Falls of a device developed by the NRC to measure low voltages; I recognized it. It was referred to in this supporting brief. I should like to emphasize to Dr. Schneider that we, in this committee, are all laymen in assessing performance of an agency such as yours, and we have to deal with rather pragmatic considerations. I think, therefore, that because of our

interest in your agency and our lack of background knowledge, we would appreciate further expansion in some of the matters referred to in this supporting brief. Particularly, I note at page 38 there is a reference to patents, new industries, technologies and processes developed by or under the aegis of NRC. Again, further on, there is a list of some significant projects, amongst which is included the device which I referred to as being mentioned in the paper this morning. These are very cursory in their content, and I feel it would be of great value to this committee if someone in your establishment, Dr. Schneider, would be prepared to set out, for the information of our committee, say, all projects completed within the last five years, in order to give us some sort of empirical test with respect to the operation of NRC during that time. I would not expect this from any witness today, because this would involve a considerable amount of research, and I appreciate the time that would have to go into it. We are also, I think, Dr. Schneider, interested in learning not only of the specific projects that have evolved because of NRC, but we are also interested in learning how they came about, where they were conceived, how they were developed—in house, out house—who were the people involved, through what chain of command did they come about; and, incidentally, to try to show to the committee perhaps what may lie behind a reference to some chemical here which was developed by the NRC and which, through one reason or another, either competitive interests outside or some other reason, failed to gain commercial application. These are very specific, non-esoterical matters that I think could be of great interest to us, if you would be prepared to spend the time and trouble with your staff to develop this for us. I think that in this way we could get a more exact evaluation of your performance.

Dr. Schneider: We would certainly try to provide the committee with this information. I should point out that if you say a project is "completed", research is not something that is turned off and on over a short time interval. This is usually fairly long-range exploratory research, and very often some new idea comes out, such as this very new potentiometer, and the people in this area suddenly seize on this and then develop it. Many of these projects are not going to be "completed", let us say, if you only consider the last five years. Some may still be going on, although there has been some progress which has been very beneficial, and many of these studies will continue to go on. I think we could attempt to document these, although we cannot provide this information this afternoon.

The Chairman: I think what the senator wants is a case history of your projects, and I am sure you have that somewhere in your files, because you have to monitor all these projects. So, it might be a problem of compiling these things, but as far as we are concerned, I think it would be of great interest.

Dr. Schneider: I might just add that very often it is very difficult to assess many of these in the short term. Research needs a lot of lead-time it is a long-term affair; and we have wrestled with problems of cost-benefit analysis, and so on. In retrospect, for something done many years ago, you can now see the economic benefits. One has to trace these through the various sub-channels, but I believe this can be done in retrospect and we have people working on it, to try and assess things we did some years ago; but with regard to things completed in the last five years, the economic benefits are just beginning to be apparent, and it is very difficult to project this into the future.

So, I think the whole question of the economic benefits is a very difficult one to assess, but we are attempting to document this for some of the things we did, say, 10 or 20 years ago, and which are now in use—and some of which are paying off very well.

[*Translation*]

Professor Bonneau: I could add two examples which come to mind—one rather recent, the other much older, in line with the Senator's question.

The first concerns a submarine television set.

At the time—this was at the beginning of the 50's—submarine television was completely new, and there were enormous technological problems.

For a specific reason, the Council had developed a set; it was available and was offered, in a general manner, to the Canadian market. It was manufactured afterwards in England. The Canadian market, at that time, was not interested in it.

Much more recently, a photogrammetry instrument, developed in the Council's laboratories and nearly perfected, was finally

produced in Italy—here again the Canadian market, or industry, was not interested. I believe this is also on the list suggested by the Council.

This will happen again, because I believe we have here the key to the problem, in many cases of research and development. An idea nearly reaches maturity—the point is reached where the laboratory cannot handle it any more, and it falls flat, or it is found elsewhere, in other countries.

[*English*]

Senator Connolly (Ottawa West): Could I ask you on that point, in English—and this is a supplementary question, Mr. Chairman, if I may...

The Chairman: Just because you are a former Leader of the Government, I will permit it.

Senator Connolly (Ottawa West): In either case, in either of those devices, was there a patent taken out either by NRC or the organization that put them to practical development?

Dr. Schneider: I am sorry, I did not hear the question.

Senator Connolly (Ottawa West): Did NRC take a patent on those processes, or did the developers take patents?

Dr. Kenneth Franklin Tupper, Vice-President (Scientific) National Research Council: NRC did take patents.

Senator Connolly (Ottawa West): So that there is a return?

Dr. Tupper: Yes, there is a royalty. The royalty goes to the Canadian Patents and Development Company, which will be appearing before the committee at a later time.

Senator Aird: Mr. Chairman, Dr. Schneider, I would like to ask a question that relates like to correlate that question with page 1 of your very large submission.

The first sentence on page 16, item 8, reads:

> Finally, I should like to comment on the future role of the National Research Council in the evolving national framework for science. Under its Act, the National Research Council was set up as an independent agency of the federal government with a broad responsibility for science. With the recent establishment of the Science Secretariat and the Science Council, both with strictly advisory roles, the National Research Council continues as the main operational agency in the science area.

That is my first reference. I should like now to shift to your other statement in the large brief.

The Chairman: At what page, Senator Aird?

Senator Aird: Page 1, Mr. Chairman:

> The broadly representative character of the Council itself, as well as a strong cadre of advisory and associate committees, provide the Council with the board and detailed input necessary for decision-making and policy formulation on all aspects of scientific research in Canada.

What I believe this committee is concerned with, Dr. Schneider, is not only the future role of science policy but also the present role. We are concerned, I think, with management and priorities. So what I would like to have discussed by you is the mechanical interrelationship of the Science Secretariat, the Science Council, and the NRC. What I am seeking is the trigger in the decision-making process. What is the management? Because, sir, if you take this sentence that I have read from your large brief at its face value it would seem that the NRC discharges that function adequately at the moment. In fact, the first thing that occurred to me when I read that sentence was that there probably was no necessity for this committee at all. That is putting it fairly bluntly, but this is the area about which we are concerned. We are concerned about priorities and management. I would like to hear your comments on that general statement.

Dr. Schneider: Thank you. May I, first of all, correct a misprint on page one of the larger report. That phrase should read "provide the Council with the broad and detailed input necessary"; the word is not "board". That is a misprint.

Since you have also alluded to this committee I should like to say that I think it is serving a very useful role for the scientific community, if not for the Government. Looking at it from the point of view of the scientific community, I think it does provide a public forum where many of these issues can

be discussed, and this is something that is needed because, as you know, it is very difficult sometimes to get a consensus in the scientific community. In this committee you will hear all sides, and everybody has a chance of making his case, and then I think it is easier to arrive at a consensus.

On the question of the relationship between the National Research Council, the Science Secretariat, and the Science Council, I would mention that the specific roles of each are laid down in a statutory way. In practice, the Science Council concerns itself specifically with broad policy formulations. Of course, the Science Council has not been in operation all that long. They are still working hard at it. We do not yet have a complete integrated overall science policy emanating from that body, but this is the intent.

These science policies, presumably, will be formulated in rather broad terms. In other words, these are the desirable directions for us to go. Beyond this there still has to be decision-making, and decision-making involves not only deciding that these are good things to do and that they have high priority, but also the finding of funds.

This is not, of course, a case of the NRC deciding something is good and then going ahead and doing it. There has to be consultation within the Government structure, and ultimately it means decision-making at the Government level. Once the general policy framework is there then certainly any programs that the NRC develops must be consistent with the broad policy objectives.

Of course, if there is a vacuum and there is no policy, and yet there is a national need or a very urgent need, we will endeavour to try to do something about it. I think it is entirely proper for the Council to take the initiative where they see new opportunities or an urgent need to do something. Then, if it is a major program and it involves major expenditures, it will again go through the usual Government channels in respect of decision-making.

But, on the whole, as I see it, and as we succeed in developing a more integrated overall science policy then I certainly think any operations which the National Research Council carries out must be consistent with those overall objectives.

I might say that I have been recently named as a member of the Science Council, so I should be completely knowledgeable in my thinking there, but on the whole there is the fact that some of the members of our Council are also members of the Science Council. So, there is this overlap of information, and I think we can work together very closely in this way.

With respect to the Science Secretariat there is again a very close co-ordination. We are in almost daily contact. Of course, the role of the Secretariat is somewhat different from that of the Science Council, but we do have frequent consultations in an endeavour to work together towards common objectives.

Senator Connolly (Ottawa West): Does the Science Secretariat work under the direction of the Science Council?

The Chairman: Not yet.

Dr. Schneider: The Science Secretariat works in the Privy Council office, and presumably reports to the Prime Minister.

[*Translation*]

Senator Bourget: Dr. Bonneau was speaking, just now, about pure research and applied research. While reading the report submitted by the Canadian Engineering Institute to industrial organizations, I notice on page 10 the mention that Canada spends ten times more... and the United States and Sweden are mentioned—in this report of the Canadian Engineering Institute, the committee of which Dr. Bonneau was a member—it was recommended that more money be given to applied research than to pure research. Could you give me your opinion?

Professor Bonneau: Mr. Chairman, I think this is the meaning of the question: Senator Lang had set the problem, it seemed to me, in a way which led to believe—and this is how I understood his intervention—that the Council had done much more, and nearly exclusively, research in the so-called pure sciences. I have tried to show that the situation was much larger than that, and that there had been much research, in certain cases, on the applied side; but this applies solely to the Research Council, to its activities in the laboratories, and to the subsidies it has granted across Canada, especially in the universities. The fact remains that the basic problem is perhaps not there; but, what has been set forth remains, in the industrial sciences,—legislation by the federal government to promote development in industry. We could have laboratories which will supply

many ideas which we would later carry out to their usual development. If our legislation —our policy—is not such that these ideas can be developed in our country, as in the two examples I have mentioned, these products will be found again on a foreign market, and we will buy them there.

This percentage of 13 per cent, which has not changed since 1959-1963, and which will not change until 1977, is very symptomatic of our structure, where development was carried out in Canada—with a few exceptions. This is the general idea of the report you mention and which had given rise to discussions on the efforts to be made, especially in research and development—and more particularly the development aspect, which is usually carried out in local laboratories—perfecting, market research, production problems and problems of introduction on the market, with consumers' reaction. This is how, for example, we have succeeded in producing a better egg-beater than we had before and in selling it on the market. The whole industry grows with this kind of continual technical input.

Senator Bourget: Does this situation mean that the financial aid, which is granted to research, is not large enough on the industrial side?

Professor Bonneau: Many people will say so. Is this the key to the problem? Personally, I would not say so. There are many other fields referred to in the brief—not just this one. Money might have been used to advantage, perhaps, in promoting research in industry. We might also have put to good use, in Canada, the results of successful research conducted by neighbouring nations rather than promoting our own. There is a whole structure to be built. We are beginning to recognize the real problems. Ten years ago, people were crying in the wilderness. Today we recognize the problems, we are able to cope with them. I feel that the brief to which you allude and the present brief are both heading in the same direction.

Senator Bourget: In the Glassco Commission report, reference was also made to a certain aerospace company which had not received financial assistance or that it was not adequate enough to our industry to continue in research. This is why I raise the following question. Is financial aid to industry, that is, financial aid extended for pure research, inadequate?

Professor Bonneau: I do not know whether the question is applicable as regards subsidies for pure research; I would say no. The basic fact is that pure research must be subsidized. There is no way of constructing a good, autonomous, autochthonous technology without that basic reserve of scientists who know something about metals and other matters important for technology. But above this foundation, a structure must be built; in this respect Canada at the present time has next to nothing. But when we look at the field of pure research we can be rather proud; we no longer have the right to hold reservations regarding our efforts in research, efforts which are highly interesting and autonomous in Canada. It is in the small sectors, or perhaps an average sector, that the question arises and yet it might be admitted that Canada is perhaps not too badly off in this area. But, on the level of research and development in industry, the picture is much grayer, if not black.

[*English*]

Senator Grosart: Dr. Schneider, I am sure that you and your associates appreciate the fact that in this committee we, by our terms of reference, are concerned largely with the mechanisms of the making of science policy by the central government. From the evidence we have had this would seem to involve the two main questions of science in policy and policy for science. You have answered some questions on the first part, but I think Senator Aird's concern, in its broadest terms, is whom the politicians should listen to.

I say that because we are talking of decision-making. There is decision-making at all kinds of levels. The National Research Council has made a very substantial policy decision in what you call the main operational agency in the science area. I am not criticizing your decision; I am merely saying that as I understand it your decision seems to be a policy decision in this main operational area, that of the sums available to you of, say, $120 million, leaving out the Medical Research Council, $45.8 million goes into intra-mural research, $51.4 million into R. and D in universities, and $6.1 million into support for R and D in industry. I am suggesting that this is a policy decision.

I wonder if it will, in the future, meet the problems that have been raised if the National Research Council continues to be the policy-making body in this area. As a layman looking through your projects, hundreds of

them, I could not tell you what most of them are, they are in technical language. I am sure this applies to the ultimate decision-makers at Cabinet level. How do they know that some of these things are not errors or ill-advised? This is one part of the question.

If the National Research Council is not to make these decisions, who is? You have said, of course, that these things are discussed with the departments, with the Science Council and with the Science Secretariat, and no doubt many others, but are not you usurping a policy-making decision in doing these things? I am not saying you should not usurp it. My point is that the decision-maker in a society such as ours has to be a political entity which has to take the responsibility. If any of these projects of yours prove to be, say, ill-advised, some politician may get his head chopped off. This has happened in our political experience in the last few years.

My first question therefore is: can you tell me how you would suggest this input of science into policy-making could be carried on in a more efficient way than it is at the moment? In relation to that question I hope that Senator Hays will give you some horrible examples, which I would like to hear you comment on, of things that happened in the department when he was minister. He told us in this committee of things that were utterly absurd, a waste of public money—and he used that term—and he said he could not stop them as minister. We asked him why and he said, "Well, the civil servants told me they would be here a long time after I had gone."

Senator Connolly (Ottawa West): That is no longer true.

Senator Grosart: I am not worried about the past really; I am just taking this as an example. Obviously you have had to fill a gap over the years.

Senator Aird: We are worried about the present.

Senator Grosart: I am worried about the future, because this is our job in this committee. You, as I understand it, suggest to the Government what should be science policy, how it should be made, and how it should be controlled. Can you suggest to me from your vast experience how the National Research Council can fit into this or where it should fit into this?

Dr. Schneider: This is a very big question, and a very important one. I have some thoughts on it, but first I would like to let Dr. Tupper reply.

Dr. Tupper: Mr. Chairman, I think we must distinguish here between the making of a policy and the implementing of it. Senator Grosart has read off the sums of money being spent in certain sectors, and I think the implication of his question is that the National Research Council took the decision as to what fractions of this total money should go into each of these sectors. This is not the case. The sectors have been identified, in many cases years earlier, as sectors worthy of federal support, so that money has been allocated to these programs. In the case of industrial research assistance programs, it dates from 1962, and is not as old as university support programs, or other programs which are quite varied and which are described as intramural programs.

Senator Grosart: May I interrupt you? I was interested in noting that in the case of the industrial assistance program you went to Cabinet, gave them certain advice, and waited until they got an order in Privy Council. Do you do this with a large percentage of these programs? Why did you pick out this one to go to the Cabinet?

Dr. Tupper: I cannot answer the question as to why that was picked out to go to Cabinet. I was not with National Research Council at that time. Dr. E. W. R. Steacie, the president at that time, has died and only he could have answered that particular question. The point I am making is that in general the proposals of the council are put forward through their minister to the Treasury Board, and they have to compete for the funds available. The decision as to how much will go to the National Research Council, and, indeed, how much will go into each of these individual programs is not taken by the council. It is taken by the cabinet committee known as the Treasury Board, and they take the decision in preparing the estimates which are tabled in the house. They consider the importance of these activities in their own minds. When it comes to the implementation of the policy as to whether Professor X should get a grant for his work in physics or Professor Y should get a grant for his work in biology, this comes within the terms of reference and the capabilities of the Council.

I think honourable senators will be interested in knowing that there is a profound change going on at the present time in the

process of decision making and the allocation of funds. This goes by various names; it is generally called program planning and budgeting. Here all the things that the federal Government does are confined into a fairly small number of sectors, relations with countries abroad is one sector, defence is one sector, economic measures is one sector, social measures is one sector. I believe there are less than 10 of these altogether. Decisions as to allocation of funds may first be made by sector, then the individual sector is broken down by various programs of activity. This is going on at the present time, so that decisions as to how money is spent on science are not made by the National Research Council until many more important decisions on the relative importance of programs have been taken by the government of the day.

This perhaps has not disposed entirely of the senator's questions, but I think it is fair to state that on science policy, so far as NRC activities are concerned, the arrival of the Science Council or Science Secretariat is a fairly recent event. The council has each year to take some action and to exercise its responsibility, always recognizing that the minister carries the ultimate responsibility for the spending of this money. To this present date any indication as to the relative importance of things or the formulation of an overall science policy has not emerged from the Science Council. We have still to be responsible for our ongoing activities on the basis of our own judgments. This is a question to which one could speak at very great length, and I will be happy to amplify my remarks if it is necessary.

Dr. Schneider: I would add something to this; there are a number of areas where we have separate parliamentary votes. For example, industrial research comes under one particular vote; university research and scholarships comes under another. When you speak about decision making, this must be kept in mind. We cannot, when the votes are established, make decisions involving the transfer of money from one vote to another. As Dr. Tupper explained the programs are presented, the case is made, and there is decision making which is outside the council. Once these votes have been established, we have to make decisions within these votes, and we have to take the responsibility of making the best use of this money.

Senator Grosart: I am not too concerned with the fact of decision making within the science area by the National Research Council, but I am concerned with the first phase of science policy making by a government, that is the input of science into the broad decisions as to policy. I wonder, for example, who took the political responsibility for these broad funding decisions or whether the political decision makers knew it was going to wind up in this breakdown of $45.8 million, $6.1 million, $51.4 million between in-house, industry and universities, because a minister, Mr. Drury, is now saying this breakdown is a serious problem. In a speech he made recently to the Chemical Association in September, which I think summarized the problems of the Government on policy making, he said:

> I suppose the most fundamental question to be answered is what level of research effort the nation should support—

And the second is:

> ...the distribution of the scientific effort between basic and applied science.

We are in the year 1968, and a minister, despite 50 years of experience with National Research Council says "We now have to find the answer to the vital questions of government science policy."

It is rather interesting what he says about distribution of our scientific efforts between basic and applied science. He describes it as:

> ...between the generation of a new knowledge and the practical application of the vast pool of scientific and technical information which already exists. At present, our overall science effort is preponderantly—

And here he is talking of the whole national effort—

> —in the research area whereas development activity which is the immediate precursor of commercial exploitation constitutes only 37 per cent of the total. For a nation whose industrial development is still in the evolutionary stage, it would seem that greater emphasis should be placed on the exploitation of technology and our research effort should, in the main, be directed toward supporting this objective.

Now, you have endorsed this in your brief, and in those of your speeches which I have read. But again I come back to this question of how do we or how should this committee

recommend that this bridge be crossed between the input of science and political policy making. I don't readily see the answer when I see the minister going on to say the third big problem is the allocation of our scientific effort as between the public and private sector, and then that we may need a specialized agency within the Government. The next one is the role of the Government laboratory. Most of all of this is directly concerned with the role of the NRC in this future complex of political policy-making.

The minister refers to the Engineering Council recommendation, and then comes back to what he calls the most fundamental question. He is talking of the industrial front. He says the most important policy question is the financing of industrial research and development by public funds and the most effective means of applying those funds.

Can you comment on the role of the NRC in the future, in helping the decision makers to answer these questions?

Dr. Schneider: This is a very broad problem and one that will always be with us. For example, decisions on how much money should be put into basic research and how much into applied research, and so on.

As far as industrial research is concerned, the Department of Industry also has been involved and we maintain very close contact with them.

The big problem is, what is the best way? We obviously have a problem here. We want to promote and encourage more industrial R and D, and more industrial innovation. The industries apparently are not able to do it themselves, they need some kind of help, some kind of incentive. What is the best way to do it?

There are several programs and I think it is clear now that these are not going to be sufficient, that more has to be done.

Therefore, the first step is to review what we are doing. What are the problems? Why are they not effective? What more is needed? What kind of program? Certainly, a tax incentive program is one way of doing this.

Also, it comes up time and time again, that there is no use in doing a lot of industrial type research in Government laboratories or universities if the industries are not there to take it up and exploit it. Ultimately, this has got to be in industry, so we might say perhaps that we should in the first instance try to encourage more of this in the industrial laboratories and then they are in a position immediately to exploit it.

What kind of programs do we need for this?

We must do more comprehensive studies than in the past. We have started on this and will be working with the Department of Industry on this.

We need to look at this whole question very seriously, as to how we can promote and encourage this kind of development in Canadian industry to build in more advanced technology, because if they do not involve themselves with more advanced technology now, they will be in trouble and lose out, and that may mean getting a certain amount of secondhand imported technology from outside, but we will not be leaders in anything.

I consider this has to be one of our most urgent problems at the present time. This is not an easy problem. It is not so much a matter of what we spend in fundamental research and applied research but rather how we can get some of this activity into industrial laboratories, to be undertaken by industry. University laboratories, Government laboratories, can give a great deal of backup assistance on that, but when you get into project development, innovation and exploitation, this is best done in the industry.

Senator Grosart: I can specify examples I am concerned with in this. Taking this $51.4 million which has gone to the universities, here we are in an area of political decision. We decide that post secondary education is not "education" for constitutional purposes. I am not criticizing that decision. But this is a sensitive area.

You decide to put about half your money into support of universities. I do not criticize this, but I say "Are you not treading on dangerous ground when you assume the responsibility of making this kind of decision?"

Dr. Schneider: Again, let me correct this, because the funds that are voted for extramural support of universities research and scholarships is an entirely separate Vote, a separate program, and has to be assessed on its own merits. Once money has been approved for this, this money can be spent only for these purposes. So, this is not a decision of the Council. There are a lot of other factors.

The Chairman: You are really at the beginning of the decision-making process when you

apply to Treasury Board for the approval of a certain program. In other words, whereas ultimately your programs have to be approved by Treasury Board, by the Government of the day, and by Parliament, at the beginning you do have much to say as to the allocation of resources.

Dr. Schneider: When we submit the Estimates, and since this is an external support program, we make the case on the basis of demonstrated need. Of course, this was also the policy not only of the federal Government but of provincial governments as well, to strengthen and build up universities, so that we would have more trained manpower.

I should point out that we support only graduate research: we are not concerned with the undergraduate programs.

The growth of the universities has been such, and the number of students has been such, that there had to be this escalation in this program, because we still had a continuing shortage of manpower.

We have come to a stage now where we have to look at this. Unless there are many more opportunities opening up in industrial research and applied sciences, there may not be the same justification for the kind of increases we have had in the past.

Senator Grosart: I am not making any objection to the support you have given to universities, in any way, shape or form. But what would be the answer, if the question were raised: "Why are the respective proportions of public money going into these three main sectors in Canada so different from that in other countries?" For example, we are the lowest of all the OECD countries in public founding of industrial research, I understand.

Dr. Schneider: I mentioned this before, and perhaps we should understand the particular situation in industrial research. Beyond that, I should say I do not think the comparisons with other countries should be taken too literally.

For example, this is a country with tremendous national and natural resources, so naturally the first step is to develop these—and this is why we have research in the Department of Agriculture, in the Department of Energy, Mines and Resources, in the Department of Fisheries, in the Department of Forestry and so on. There are tremendous natural resources to develop. Of course, this kind of development would not be the kind that industry would normally do by itself, so we have a lot of Government research and Government departments specifically related to development of natural resources.

Many other countries do not have these resources so you do not find these research departments in other countries. This explains to a large extent why we have in this country relatively more research on a percentage basis in Government laboratories than in some other countries—that, together with the fact that we have so little research in industries.

This is the picture here. We have certain problems, as you know. We have many foreign-owned companies, subsidiaries of parent companies, where they have been able to import quite a lot of technology. This, if you like, explains the past pattern but I do not think any one of us would agree that this is a proper or appropriate or acceptable pattern for the future.

Senator Grosart: I notice the suggestion has been made that a realistic role for the NRC might be confinement to this area of basic research or pure research, whatever you like to call it. I see you anticipated this, in the closing paragraph of your brief. Would it not make sense for the NRC now to assume this specific role, obtain a grant from Parliament for pure research, and confine itself to this?

I do not necessarily mean that you have to work in isolation, as you suggested here, but in co-operation with others. If the NRC took on this one such function, would this make sense?

Dr. Schneider: In my view, no. If this came about it would be pretty hard to justify the existence of the NRC at all because, while it was not true in the past, we now have some very strong research laboratories and universities doing basic research. Therefore, why have an institution which concerns itself only with basic research in a government establishment? Even though we do a certain amount of basic research—and this is really to back up the applied research programs that we are carrying out and to enable us to have an awareness of front-line science so that we can do a good job in the application of science and be aware of new opportunities—you have to have some activity in front-line science. It seems to me the real strength of the Council would be in bringing all these together and taking an overall view of the needs of the country. The co-ordination and

development of programs in the directions we want would then follow.

Senator MacKenzie: Mr. Chairman, I should just like to correct one impression that Senator Grosart gave. He made frequent reference to the Council supporting universities. Now, as a former university administrator, our quarrel with the Council was that the universities did not get anything from the Council. It all went to specific research or the training of manpower. We did not get enough, naturally, even though we did try in the early days to get, I believe, 15 per cent, or whatever it was, but without much success. It is better now. However, I think it should be clear that this is not in the report of universities on the operation of science.

Senator Grosart: I was taking the statement at its face value; Appendix M, page 2, item 6 reads: "Support of R & D in Universities, $51.4 million".

Dr. Tupper: The Senator should read the word "partial" in front of the word "support". The National Research Council's support is never complete support. This is even more true in the industrial sector, as you may have read. This is a shared-cost program, and I think the senators would be interested to know that during the first five years of the Industrial Research Assistance program, some of the funds allotted for it lapsed. In other words, more funds were made available by the National Research Council than industry could take up.

Senator Grosart: What is the position today?

Dr. Tupper: We have essentially run out of funds during the present fiscal year so we are in approximate equilibrium.

Senator Grosart: What percentage of requests last year for industrial assistance had to be turned down because of the lack of funds?

Dr. Tupper: Last year there were none due to a lack of funds. However, this fiscal year we have had to defer some decisions until later in the year, or until we know precisely the closing balances.

Senator Grosart: Is a minister of technology the answer?

Dr. Schneider: Many countries are experimenting and have various structures of this kind. I do not think that any country has found the right solution. These are very difficult areas. You have many things to put together here, and I think that certainly if what we call indigenous science were put under a minister of technology it would not come off too well. We do have a department of industry which has been attempting to play the role of a minister of technology. Of course, there are various other forms this can take. I do not think this question can be answered.

Senator Phillips (Rigaud): I should like to add to Senator Grosart's question on that point. Would Dr. Schneider say how many of the OECD countries have in fact ministers of science and technology. I just wish a rough idea.

Dr. Schneider: They vary. I believe several European countries have something which is similar to a minister of science and technology, but in most of these countries education comes under the federal Government. Therefore, there is a minister of education, and the ministry of education supports university research. The build up of indigenous science to train manpower in research very often comes under the minister of education. This is a continuing support program which, in addition, can also include applied science projects which can come up through various ministers or through the minister of technology. This would perhaps provide funds for projects in universities and industries and other laboratories. This is, of course, supplemental, and as far as the universities are concerned, perhaps an additional amount over and above what is supplied by the minister of education could be allotted.

In Canada, of course, we do not have a minister of education to perform this function therefore this kind of structure would not work.

Senator Grosart: May I make a suggestion? It refers to the guidelines prepared by the steering committee. Naturally when we receive a brief we look at the guidelines to see what has been incorporated. There are quite a number of questions that we asked that are not answered in your brief. I agree that you must have latitude as to what you are going to answer and what you are not going to answer.

On page 9 we asked you to describe the process whereby various types of programs

and projects are selected, initiated and monitored. For example, what role do other federal agencies or units play in this process, and how are priorities established between programs and projects, and in what terms are priorities expressed and supplemented? My suggestion is that perhaps you could take a few case histories and trace for us the decision-making process. They are all decisions along this same line, that is, the decision to initiate, the consultation with others and the clearances all the way up to the time they go to the Treasury Board. I believe it would be very helpful if you would give us one or two cases as examples because some of us are wondering, when we look at this tremendous list of projects, how the decision was made to undertake them. I am not being critical in any way; I am just seeking information. If we could have a few case histories it would illuminate this whole matter. Thank you, Mr. Chairman, and Dr. Schneider.

Dr. Schneider: You would like us to prepare this information for your committee?

Senator Grosart: Yes, in terms we could readily assess.

Senator Cameron: Mr. Chairman and Dr. Schneider, I agree, after observation, that it arises out of the question asked by Senator Lang about the amount of commercial revenue. In effect, it has come out of patents developed by the National Research Council. I think it is very important that we have this answer, and I will give an illustration in the following way. If you go to the western prairies and talk about the work of the rust research or the work that was done by the NRC on frost resistance and wetness with which western farmers are familiar, it is not too difficult to sell them on the need for supporting this type of thing.

The point I am making arises out of Senator Lang's question. I would appreciate a number of illustrations such as work done by the NRC and how it is translated into economic terms. It would make it much easier for the Government to get funds and for industrial firms to allocate funds, as well as making it less complicated for the public to understand where their money is going. I think this is a very important question.

The next question I have—and I suspect others have the same doubt—is about the role played by the Science Secretariat in relation to the Science Council. Now, if I can make a clear distinction, I think the Science Secretariat operates on a political level rather than on scientific level. The Science Council makes the policies, and the Science Secretariat advises the Privy Council, and, of course, it has a larger role, keeping an eye on what is happening in other countries; but would you define, very briefly the role of these two institutions, the Science Secretariat in relation to the Science Council?

Dr. Schneider: First of all, on the first part of your question, we have, in the report we presented, just given a few examples of the kind of thing you are talking about. One was the rapeseed problem, the answer to which was developed in conjunction with the Department of Agriculture by our Prairie Regional Laboratory in Saskatoon, which is, as you know, now a multi-million dollar crop. Of course, one could try to estimate some of the economic aspects. It is, of course, still expanding. It involves also the whole edible oils industry, so it is at least possible to do a partial cost-benefit on this kind of thing. But there are other areas where this becomes very difficult. For example, you develop a small modification of an aircraft in our laboratories. This goes into use. Certainly, this could involve a multi-million dollar situation, but it becomes much more difficult to separate out this part of it from all the other economic considerations.

On the question of the relationship with the Science Secretariat and the Science Council, I am not sure that I am competent to say very much about this. I think this is a matter which is frequently under discussion, but I really have no expert knowledge on what the relationship is or what it should be, as far as the Science Council and the Science Secretariat are concerned.

Senator Cameron: We have top scientists in the country on the Research Council. Why could not a committee of that Council...

Senator Connolly (Ottawa West): On the NRC?

Senator Cameron: Yes—advise the Privy Council? I am not clear as to the necessity for these other bodies.

Dr. Schneider: This takes us back through history. At one time our Act stated specifically that the National Research Council was to advise the Government, among its other duties, and when the Science Council was set

up this was removed from our Act, the thinking being that since we are an operating agency, the Science Council not being an operating agency, but a purely advisory body, the two functions should be separated, and this was the distinction made at that time. So, at the moment although we will certainly give advice when we are asked for it, we do not have the duty to advise the Government.

On this whole question of decision-making with respect to science matters, I think at the present time we do require some kind of central focus within Government which, I think, has to be at Cabinet level, where these questions can come up, where decision-making can be focussed; and it also means they would require probably a committee or one man who would require some research help. I think we have lacked this kind of focus. Of course, we do have the Privy Council committee on Scientific and Industrial Research, which is composed of a number of very busy ministers. I think this is really the problem, that Cabinet ministers are very busy people, and many of these questions are very involved, and unless someone has the time to study these, it is very difficult to make decisions.

Senator Aird: Do you have a recommendation as to how the Cabinet might be best advised?

Dr. Schneider: I do not think I have a recommendation. I think this is really a matter for Cabinet to work out. I think that, certainly, as a result of the considered deliberations of this committee it will become apparent how complex these problems are, and also perhaps indicate some sort of structures which would give this kind of focus for decision-making.

Senator MacKenzie: Could I ask a personal question, one not particularly relevant but interesting? Dr. Khorana received a Nobel award recently. Would you not think that Canada could possibly claim, with India and the U.S., some of the prestige that generated, in view of the fact the work for which he was given that award was started and carried a fair way in Canada?

Dr. Schneider: I think this is a case of a very able man who was at the time working at the British Columbia Research Council...

Dr. MacKenzie: At the university too.

Dr. Schneider: ...Not at the university. But I think that at the time he very much desired a post in the university. Apparently, none was available, and the environment there in which he was working was not the best.

Dr. MacKenzie: We wanted him, but he could not come.

Dr. Schneider: Dr. Khorana did most of the important work which led to the Nobel prize while he was in Vancouveer.

Dr. MacKenzie: On that campus!

Dr. Schneider: And, of course, the work that he has done subsequently at Wisconsin has been a further elaboration of this, but all the important work was done while he was here for about eight years in Canada. It is unfortunate we could not have made it profitable for him to stay.

Dr. MacKenzie: If I could explain that in his terms, it was not because there was not a post available and it was not because there was not money available for him to carry on; these had been assured. But he felt that he had pretty well exhausted, for him, the possibilities in British Columbia, and it was time, in his development and career, that he went to another environment in another place.

[*Translation*]

Professor Bonneau: Mr. Chairman, may I return to the first part of the question regarding the way in which national scientific policies might be oriented towards local or regional problems?

The Chairman: Yes.

Professor Bonneau: I feel that the subject is an extremely important one and one which at present should be introduced very explicitly within the legislative system; I do not know whether I should expand on this—but, right at the moment, it is a very important issue.

In the brief, reference was made to two cases: the Atlantic provinces and the French universities, but I realize that the problem is much wider than that.

Reference was also made a little while ago to research conducted by the National Research Council in the Prairie provinces. Here is a clear example of a local project which can readily be measured in terms of output as we are now able to observe and

evaluate the crops resulting from our experiment. But I should like to suggest that perhaps your committee could also assess the importance of our scientific policy on, let us say, the location of laboratories attached to certain departments. I am thinking of Agriculture, the Defence Research Board and several others which have laboratories across Canada. These laboratories first provide an input for the local economy. When there are 1,000 persons working in one of these laboratories, the national economy is notably affected; in many cases, as we have just mentioned, the regional economy is greatly boosted as well.

In addition to a national effort towards the solution of the major problems confronting Canada, I feel that the country would benefit from a scientific policy—something the government also seems to desire—by which, referring to the scientific effort of a national laboratory, federal laboratories would deal with regional problems. In this way, I feel Canadian scientific efforts might be remarkably strengthened; if not, political disputes which could erupt in Canada might, in certain cases, destroy a major part of our scientific work, if this work were not already spread out across the country.

At present, in a number of instances, we might say that research is being carried out in Ottawa but not elsewhere.

I feel here that if we included certain guidelines in our development policy regarding the establishment of laboratories, an important step would be taken towards the strengthening and promotion of Canadian scientific achievement.

Senator Bourget: Have their not been efforts to decentralize research, to incorporate research into our Canadian university system as Dr. Schneider mentioned a little while ago? Has their not been a more marked effort to assist research in our French universities, for example? Have laboratories been specially established? Has more general financial assistance been given to French universities?

Professor Bonneau: I do not feel that we can reply in the affirmative to this question if we mean that the projects were financed because they emanated from French universities. We lately had a project in mathematics at the University of Montreal. The Council simply chose this department in the University of Montreal because it was considered one of the best in Canada and because the University of Montreal had a viable programme which could be developed.

My suggestion was not entirely along this line but concerns a level which, although national, would have regional implications, that is, would require an effort, as the Council has done, to recognize regional problems—for example, in Halifax and Saskatoon, the problems of fisheries and crops—where laboratories have important inputs. There is a way of doing the same thing for almost all the areas in Canada.

Senator Bourget: At the present time, do you have a programme for the area with which we are concerned?

Professor Bonneau: I should not like to venture any details today as the projects are still in the drafting state and many facts have yet to be accumulated; this cannot be done overnight; the area must welcome the project and bring it to a successful fruition and often this is an enormous problem.

[*English*]

The Chairman: I think that this is an appropriate time so to adjourn. I know some people have appointments, and they also have to eat. We will resume at 3.30 this afternoon.

The committee adjourned.

AFTERNOON SITTING

The Chairman: The meeting is open.

Senator Sullivan: Mr. Chairman, Dr. Schneider, my colleague from the University of Toronto, Dean Tupper, Dr. Bonneau—I know a few of them.

Senator Grosart asked a very pertinent question right at the conclusion of his remarks to you, Dr. Schneider, and before I come to that, it is a pointed question and may be a little difficult to answer, but as a medical man I am particularly interested in the relationship of the Medical Research Council today and the National Research Council.

Is there much medical research still being conducted by the National Research Council?

Dr. Schneider: First of all, as far as the relationship is concerned between the Medical Research Council and the National Research Council, as you know the Medical Research Council was formed, or set up by the National Research Council initially.

Senator Sullivan: Yes.

Dr. Schneider: Up until this summer the Medical Research Council reported through the National Research Council, but has pretty well functioned as an independent body and had its own Parliamentary vote.

The Chairman of the Medical Research Council throughout this time has been a member also of our Council and we have had the closest relationship and liaison with respect to our programs and policies and so on.

Now, when you get to the area of let us say biological sciences which, of course, are of interest both to the medical profession and also to science generally, there is always going to be an area of overlap and this we have sorted out amongst ourselves. Researchers in universities can, of course, apply to both bodies if it is in the area which is normally supported by either of these Councils but by and large university professors who work, let us say, within a medical school would in the first instance apply to the Medical Research Council.

Senator Sullivan: Not the National Research Council?

Dr. Schneider: Not the National Research Council; some of them do, but then we discuss this and we consult with the applicant in order to iron this out.

There will be areas, you see, that are not normally covered by the Medical Research Council; let us take, for example, medical engineering, where work might be done in a university engineering school. In those cases they may apply both to us and to the Medical Research Council.

Now, of course, very often in this research group there is also additional work going on which is not necessarily medically oriented which we would support in the normal way, but in some cases the Medical Research Council, if they feel this is of special medical interest, might also consider his application, but this is done in mutual consultation.

Senator Sullivan: Thank you; on page 3 of your brief, Dr. Schneider, you say: "...because of the unpredictability of scientific discovery new scientific advances cannot be planned or centrally directed."

Well, who directs it if the National Research Council doesn't?

Dr. Schneider: Well, I think we are talking here about completely unoriented or curiosity-motivated research, not applied research. In this case you cannot decide what a man is going to discover in advance; all you can do is assure yourself that this is a very competent investigator, that he has some good ideas and all you can do is then decide whether to support him or not, but you cannot direct his work.

Very often, of course, the most exciting discoveries, arise by chance from things in the course of a man's work; he started out to do something else but in the course of this work when he gets probing he hits on something else quite unpredictably.

So one cannot really plan this; he makes a proposal to us of what he plans to do and if this sounds like a good idea and he is a first rate researcher he will get support, but after that we pretty well have to leave it up to him and have confidence in him that something is going to come out of this.

Senator Sullivan: I was going to discusss industrial research, but I feel that has been covered very fully.

Now, the last question you can answer, and you need not, is: Is the Science Secretariat and Science Council necessary?

Dr. Schneider: Well, that is a very loaded question.

Senator Sullivan: Well, I will load it a little further: How was the decision re telescope arrived at and what roles, if any, did the above bodies play in it?

Dr. Schneider: Well, first of all, let me say as far as the Secretariat and Science Council is concerned I think everyone here probably knows the history of this, that this question was studied; this was a recommendation and it was finally a decision by government, so I am afraid this is something that is now here.

Their respective role I think, at least as far as the Science Council is concerned, is to be a purely advisory role.

I think there is probably a need to have a body that worries about very broad general directions and here, of course, this is a role that has been assigned to the Science Council.

Compared to this, the National Research Council, being an operating agency, has a responsibility to implement programs but, of course, this does not mean that we can operate in a policy vacuum. However, we have to develop policies with respect to our particular programs.

There is still a great deal of work after there is some broad policy direction as might

be developed by the Science Council; there is a long road to decision making, planning programs, implementing them and developing policies with respect to these, and this is I think a role which the National Research Council can play.

Senator Sullivan: What about the second part; what about the telescope?

Dr. Schneider: Now, here I should say that the National Research Council was not directly involved in this matter. As you know, astronomy has been under the jurisdiction of the Department of Energy, Mines and Resources; this dates back a long time, when we had a Dominion Astronomer and this was an activity which was needed in support of their various other functions, such as surveying and so on.

As to how the decision was arrived at, I am afraid I cannot answer that; I am sure there are other people who have this knowledge.

Senator Sullivan: Thank you, Dr. Schneider; that is all at this time.

The Chairman: Senator Hays.

Senator Hays: Mr. Chairman, and Dr. Schneider, I would like to discuss new programs just for a minute, then I would like to ask a few questions about new and old programs.

The Department of Agriculture with which I had something to do for a short while until the people decided that I should not be there any longer, had three pretty costly research programs. In my opinion as a layman I thought there had been sufficient research done and that these programs had outlived their usefulness.

One of those programs had to do with the use of buffalo as food for human consumption. We had a station at Manyberries, where we were crossing domestic cattle with buffalo. Thousands of acres of land were involved in this.

Anyone who knows much about the buffalo knows he has little beady eyes, that he can kick backwards, sideways, frontwards, that he has all his weight in the front end and that he doesn't take kindly to domesticating. He is a poor contributor. We have known all these things, and when we had 50 million we got rid of them and didn't restock.

A buffalo has to be crossed with a domestic bull because the female comes with the hump on her back and calf bearing is difficult.

This program started in 1917, and when I became Minister in 1964 we had a lot of cattle. Some were 17 years old and had not had a calf for five years. We were still trying to prove that there was some place for buffalo in the diet of Canadians.

I discussed this with our research people. It seemed to me that we should tuck it away in a pigeonhole, that if we did find we had made a mistake there were still buffalo and cattle available and we could resume our research. I don't know how many millions of dollars this program cost, but it must have been considerable. They are all dead now and I think it is a good thing they are. That was one program. I am wondering if the NRC examines these programs.

Then I would like to mention another one. It involves feeding alfalfa and this sort of crop to cattle. Cattle with poor stomachs have no way of expelling the build up of gas. Their stomachs become gassy, which results in compression of the heart and ultimate death to the animal. Any farmer who has lost eight or nine cows in a morning learns all about this.

We still have these programs in many locations in Canada where we grow one or two crops of alfalfa. They are also doing the same kind of work in New Zealand, in Southern Russia, and in the United States.

Senior officials of many departments come in and suggest that certain research programs be washed out because their own people have created a problem by building up an empire and carrying on beyond any useful period.

Another program we have is trying to select dairy cattle through genes and chromosomes, a program which several nations abandoned ten years ago but which we are still carrying on.

These are just three that I have mentioned. I am sure that throughout the whole field of research in Canada there must be many of these old programs which conceivably cost millions of dollars. It seems to me that the research has been exhausted and that we are on the wrong track by continuing such programs. They should be terminated and new programs commenced. I am wondering how we can resolve this problem.

Dr. Schneider: Well, I think this is of course something that one can understand how it may happen. These are rather unusual examples you have quoted; I don't think we have any as exotic as this at the National Research Council, but there is certainly an

area here where one has to periodically do a very thorough assessment of these programs and what we are doing and we have done this on a continuous basis although we were not satisfied this is necessarily always completely effective, the difficulty is that research directors are very busy people and they don't really have the time to be able to go into this in depth to try and do a complete projection and even an economic analysis if it is possible.

So we have now deliberately built into our organization a group headed by what we call délégué général whose sole function will be simply this, to analyze ongoing projects to try to project them into the future, whether this is the best way to tackle the problem, if the program is getting anywhere or whether it should be discontinued and also look at some of the programs that have been going on for a longer term, to see whether this program should be either discontinued or perhaps expanded.

This operation, which will be headed by Dr. Leslie Cook, who has had a lot of experience in this kind of area, will be supported by a staff and we expect to be going over all our programs with a fine toothcomb, to try to project these further ahead so that we also do proper planning for these programs.

Now, occasionally you will run into areas where there is some particular activity where we are providing a service, whether it is research service or with certain test facilities we have for outside users.

Very often, of course, when one suggests that this be discontinued there may be quite a lot of opposition, but I think these have to be looked at quite objectively and it may be there comes a time when either these services should be charged for, or perhaps somebody else should be doing them, but certainly it is our intent to look at these kinds of areas very, very thoroughly.

Senator Hays: My next question: How close are you to other programs in the world where they can do a better job than us? It is more important to them that they do this sort of research and that we do the sort of research which is economical or otherwise valuable to us, but not necessarily as valuable as, say, to the United States or other countries?

We have a very close relationship with these tremendous programs. What about these programs, one country with another country?

Dr. Schneider: Well, I may say we keep a very close contact and relationship with science in other countries. In some cases there are some formal arrangements for this and in others they are purely informal, but both our staff, our various advisory committees, associate committees, and so on keep fully informed as to what is going on in other countries.

We will not duplicate research that is already being done there; occasionally there are areas where the Canadian problems are different, and where we do have to do some research to adapt it to our own needs, but I would say on the whole that we are very well informed about what is going on in other countries in these various areas, and we do exchange a great deal of information.

Senator Hays: Thank you.

Senator Robichaud: Mr. Chairman, Dr. Schneider: In earlier discussions this morning the subject of priorities came up and we were given to understand that it is full cooperation between the Science Council and Science Secretariat and the National Research Council.

Now, also I think that you mentioned that the Council operates on a fixed budget, which is approved by government, by Treasury Board.

Now, I understand that from time to time different federal departments, like Public Works, Transport or Fisheries, will come to the National Research Council, say Public Works will want certain tests made on a new design of a concrete wharf. I know one experience which wasn't too satisfactory; or Transport would want research made, or tests made regarding the effect of tide and current for a ferry landing, or Fisheries want further information regarding the stability of a new hull design.

Now, after your budget has been submitted, if you got such a request, say from one of those departments, what is the procedure? I mean, who pays for it? Is it the department involved, or does this come out of the budget assigned to the National Research Council?

Dr. Schneider: If I may, I would like to refer this to Dr. Tupper, to respond to this question.

Dr. Tupper: Mr. Chairman, this is a common occurrence. Starting many years ago the National Research Council was, you might say almost unique in having certain skills. For instance, in the late 30's we were the only

agency in Ottawa with any laboratories or any personnel interested in or capable of conducting hydraulic model tests, tests of spillways, flumes, hydraulic structures, things of this kind.

Now, over the intervening years the situation has changed, but we still have a high degree of expertise in this field and we do serve to conduct experimental work where the job originates in, let us say, the Department of Public Works or the Department of Transport.

The financial arrangements for this are quite simple; we take it as a normal duty to work in this area but we cannot undertake something on a fixed budget where the cost may be proportionate to the amount of activity or the scale of the operation, so there is a procedure for using what is called a financial encumbrance whereby one department can make funds available to another department. In effect, one agency serves as a contractor to the other agency, and is reimbursed not necessarily for the whole of the cost, but for the open ended portion of the cost.

For example, we have worked with the Department of Energy, Mines and Resources and with the Department of National Defence on aero-magnetic survey work. This involved the flying of an aircraft and hence, depending on the number of miles flown by the aircraft, we would use up so much gasoline, lubricant, etc.

In such cases there is a cost that is proportional to the activity. We can be reimbursed from the financial encumbrance but not for the entire cost of the work, as we will have met a large part of it out of our own appropriation.

Senator Robichaud: A further question, Mr. Chairman: Now, in the case of, say where a department of the federal government or a provincial government might be involved, or even private industries like in the extraction or separation of minerals, for example, has the Council been asked in the past to take over such research?

Dr. Tupper: Mr. Chairman, we do undertake work for private companies or private individuals on a contract basis. This is a rather exceptional activity; it is mentioned specifically in our Act as something that we may, and perhaps should, do.

Normally we do not like to get our staff heavily involved with what you might call proprietory knowledge, that is where the client is paying all of the cost and he gets all of the rights to use the knowledge. If a patent comes from the work, since he pays the full cost he can claim the patent.

We can therefore get ourselves in a situation where we might have let us say, engineers interested in the separation of pulp from water in the paper-making process where these engineers would find they were unable to talk to any company in Canada except the one for whom they were working and all the others would be literally fenced out of the laboratory, because the research personnel couldn't distinguish in their minds between the knowledge which their client or customer had paid for and that knowledge which you could say was the possession of the Crown by virtue of research work done which was funded by the appropriation.

We do, however, undertake work of this class, particularly where we have special facilities; for instance, the National Research Council has almost all the major wind tunnels in Canada. These have been made available since the early 1930s to the aircraft industry of Canada. The firms pay for work done in them. Had we not had these facilities there would have been a situation where every aircraft company might have had to provide its own facilities over the years. Many companies have come and gone. We have had Fairchild, Nordyne, Vickers—many aircraft companies that at one time were most prominent have subsequently disappeared from the scene, either by going out of business or through take-over and amalgamation.

Now, had it been necessary to provide with federal funds wind tunnel facilities for all of these companies we would perhaps now have a collection of obsolete wind tunnels strewn all across Canada from Vancouver to Montreal.

As it is, the federal Government has concentrated its collection of these facilities in one agency. The day may come when this is no longer wise policy; however, this is the policy at this time. Much of the work that comes to NRC from industry is due to the possession of a unique research facility, such as a wind tunnel.

Senator Robichaud: Thank you.

The Chairman: Senator MacKenzie.

Senator MacKenzie: Mr. Chairman, most of the questions I had in mind were covered by Senator Lang and Senator Grosart this morning, but I would just like to emphasize my

own concern for the translation of the results of basic research into applied research in the fields of industry and commerce, because it is in this area that I think we are, as you have said, weakest.

It is understandable in a sense, because of the nature of our economy and our industries. Our economy and our industries are so similar to those of our neighbour, the United States, that it seems almost natural that we should copy what they have already produced, assuming that they have done the research and have tried it out on two hundred million people, as it were, so that we can save ourselves all the bother and cost and all the rest of it.

Despite that fact I do think it is one, and should be, one of our major concerns, as you have indicated in your report and your summary of your report.

In this connection I was very much interested in the statistics in Chart 2, in which you indicate that by 1973 you expect that there will be of the order of 11,500 Ph.D.'s at work; that 70 per cent of these will be in the universities; only 13 per cent in industry; and 17 per cent in government.

Now, I suspect that the majority, or the largest percentage of those in the universities will not necessarily be engaged in teaching, because there is likely to be a plateau in respect of the increase in student enrolment over the next five or six or ten years, but I would expect, and this is the question I put to you, whether I am correct in assuming that a goodly number or these Ph.D's in the universities will actually be engaged in basic and some near applied research work of their own in the laboratories that the universities provide and only the necessary numbers in the actual teaching of undergraduates and other graduate students?

Dr. Schneider: In reply to that I can only say at the present time there are virtually none in the universities who do not do some teaching, in other words who are doing research full time and not doing any teaching.

I think there are a few very unusual cases; I think on the whole, virtually all of the people in universities doing research also do a fair amount of teaching and the projections are that with the growing student enrolment they will need more and certainly I would say at the present time there are no plans that would set up large research institutes in a university where people are doing simply research full time and not also engaged in teaching.

I think the other matter you raised about this question of transfer of research results to industry is a very serious one and one which not only the National Research Council, but the universities are very much concerned with.

If you are going to get a lot of this transfer there has to be first of all fertile ground in industry and there also has to be a much closer inter-relationship and communication between these sectors. This is something we are endeavouring to promote, all of the universities are endeavouring to promote.

This will certainly help, but I think unless, as I say, there is a fertile ground in industry that there is sufficient research and innovation activity so that they are receptive to this it is going to be very, very difficult. This is I think one of the problems that we have to face up to and try and find ways and means of improving the situation.

Senator MacKenzie: One of the illustrations of what I have said about the number of Ph.D's in universities for teaching was brought out a couple of months ago in the opening of the Frank Forward Building for Mining and Metallurgy at the University of British Columbia, where I gather that staff almost equals the student body, not at the moment, but it does provide a very high number of staff to students.

The explanation of this, of course, is that a lot of research is being done and will be done in that building.

Dr. Schneider: That is perhaps one of the exceptional cases and I might say that this has a history, a very interesting one. They have been doing a fair amount of contract research for industry and I might say very successfully and they are continuing this as part of the university activities.

So there may be some researchers there who are not immediately involved in teaching functions. I think this is not a large activity and I think this is virtually the only department at UBC that is so engaged.

Senator MacKenzie: Yes, I hope so, anyway in one sense, but a specific question, if I may, along these lines: If a person is full time employed on a provincial research organization can he be given assistance by the National Research Council for personal research that he is carrying on on the side?

Dr. Schneider: This has been an area that has caused us some difficulty. For some years now there has been a modest grant from the National Research Council to the provincial research councils; we have not been too happy with this part, because it was so modest that it didn't really make much difference to really give them the kind of help that they wanted. Since most of these councils were tending to do some very applied work and some contract work and so forth, they needed to build up a core of scientific expertise within the organization to back up this kind of activity, and this is what these modest grants were intended to do.

Now, of course, they would like to get more support; we are studying this at the moment.

The kind of thing that is being discussed, for example, is that perhaps if they come up with project proposals, very important project proposals which may make an important contribution locally to an important problem, that perhaps we could look at this and see if we cannot help.

The Chairman: I would hope, however, that the National Research Council would not start a new system of shared programs.

Dr. Schneider: No.

Senator MacKenzie: This question, however, had to do with assistance from the Research Council to an individual outside his work, his provincial organization; he is conducting some research more or less on his own initiative?

Dr. Schneider: No, this would normally not be considered.

Senator MacKenzie: I think I understand that it is not at the moment being considered or supported.

The Chairman: Are there any supplementary questions?

Senator Robichaud: Mr. Chairman, I have a supplementary regarding Chart 2. Now, if you take the examples that are shown on this chart and convert them to actual figures: for example, from 1964 to 68 it shows 1,900 Ph.D's to be employed by government; in 1970 they forecast 2,000; and in 1973, 1,950.

Now, my question is: Is the Council contemplating that the government will not increase its activities in research, or will we remain at the present status, if the number of employees by government are going to remain at the present status notwithstanding the fact that the number of Ph.D's will be increasing?

How was this chart based, and what is the basis for these figures?

Dr. Schneider: Actually there was an sssumption and, as I say, these projections should not be taken too seriously beyond the present because particularly on the employment side this is of course very uncertain at the moment.

It was the assumption inherent here that there is a very modest increase as far as government laboratories are concerned, but even these are already out of date, because with the present cut-backs the block that is shown here, for example, for next year may come down practically to nothing. Certainly there would be nothing foreseen at the present time which would involve a very large expansion.

Senator Sullivan: Mr. Chairman, if I could interfere, isn't there a possibility that industry would take over an increased number in the future, in spite of what has been said?

Dr. Schneider: Well, this is the hope, but I don't think it will come about unless some positive measures are taken.

I think the indication we see at the present time, if we just let things ride, is that there will be about a hundred a year absorbed in industry, but there is no growth and this is the thing I think that is disturbing.

Senator Bourget: Mr. Chairman, following that, the Chart No. 1 indicated Ph.D output to be of some 2,500 to 3,000, but how in this divided between scientists and engineers, those who come out with a Ph.D as scientists?

Dr. Schneider: Perhaps I might ask Professor Bonneau to reply to this.

[*Translation*]

Professor Bonneau: I do not know, Mr. Chairman, whether I can reply to this question. I have here a document which will appear later on but which is not yet ready. To a certain extent these diagrams are extracts... This has caught me somewhat by surprise; perhaps I could look through my papers and reply in a few minutes.

Senator Bourget: Certainly.

[*English*]

The Chairman: Before any further questions are asked I think Dr. Gauvin has expressed a wish to say a few words and to comment on a question which was raised a few moments ago.

Dr. Gauvin: Thank you very much, Mr. Chairman: I would like, if I am allowed, to present a few comments pertaining partly to Senator MacKenzie's question, but also with your permission I believe that my comments would cut across many of the questions that have been asked by the senators, particularly in this morning's session, but also this afternoon.

These questions, gentlemen, show I think to me at least the concern of this sub-committee with applied research and industrial research.

Now, there is a difference between the two; applied research, as you all know, has very real technical, and to a certain extent, economic objectives; whereas industrial research has of course, the very same objectives, with the additional important ingredients of free concepts, rewards and consequences which are usually absent from applied research. These consequences, of course, are far more than financial consequences, but are social consequences as well.

Now, the question specifically in which of course the senators appear to be interested is the role and importance of applied and industrial research in Canada, and more particularly the role that NRC is playing in the sponsoring and development of industrial research in Canada.

Now, Senator Lang has touched at some length on this question and has requested our President, Dr. Schneider, to present some case histories on the ideas initially developed at the National Research Council which were presented to industry, further developed at the pilot plant stage presumably, and successfully exploited commercially.

This is obviously one of the important functions of NRC; we all agree that it is. It is almost an obvious role that NRC can play, but I submit that because of the chain of many links that leads from a question, usually you know that a research project starts not with an idea, but with the question; the idea, the fundamental work that is required to back up this idea and slowly through the various stages of bench scale work, technical analysis, computational methods of trial, then the economic factors begin, market analysis.

Then the big decision: Are we or are we not going to spend $2 million for this pilot plant? Finally, the last problem, where are we going to find a hundred million dollars to build a commercial plant.

Every one of those links is involved and I submit that NRC is not only a provider of ideas, but provides assistance and facilities in many of the links and this is to my mind as an industrialist charged with the direction of an industrial lab., those services, this kind of assistance is immeasurable. It is unfortunately intangible in value, but I can vouch from personal experience that I have used virtually every one and I have a long list of these services.

I don't know if it is permissible, Mr. Chairman, to quote from personal experience but, for example, the special emission spectro-specialized analog computers which NRC possesses, numerical analysis, special analysis, for example, the special emission spectroscope that is practically unavailable in the rest of Canada, the techniques that enable the process to become commercial, like the fluidized-bed technique developed by Dr. Gishlet, the spherical agglomeration which is being developed now by Dr. Puddington, which is not commercial yet, but we are quite aware of it and I assure you we are using it.

Of course, the library information service available is invaluable to us; systems analysis; contract research is another service which had been touched upon by Dr. Tupper already; consulting services; advice; and all the supporting services are of tremendous importance to industry.

Now, I would like to give you another specific example, this one arising from the division of building research of which I happen to be the Chairman of the Advisory Committee.

Sometimes usefulness to an entire industry does not result from an idea, but ten years ago the division was approached, again a question, how should snow loads on roofs be calculated? Well, that was ten years ago; the answer was empirical; because of catastrophic failures and very expensive lawsuits the construction people were grossly exaggerating the calculation of the engineering load.

Sixty-six actual sites were selected and over a period of five years results began to come in; correlations were established,

experimental correlations. At the end of five years a very good correlation was established showing that these empirical equations that had been used before were grossly exaggerated, some by as much as 20 to 25 per cent.

The following five years the tests continued to verify what had been established during the initial five years.

Now, the net result to the construction industry, gentlemen, was a saving in materials due to this 20, 25% beyond a safe margin of safety and it is one of the rare cases where the returns on the development could be assessed and the figures are impressive because they just about cover the yearly cost of operation of the Division of Building Research.

Of course, the trouble in R & D as has been mentioned by Senator Lang this morning, is at present the inability of correlating R & D expenditures and its effect on economic growth. The problem is an enormous one; I think it will be cracked if we have a big enough computer to account for all the hundreds of factors involved in the equation, but I think it will be cracked.

Now, concerning Senator Mackenzie's comment on the Ph.D programs and utilization, I think I would like to reiterate Dr. Schneider's cautious statement that these predications are based on existing conditions; they do not take into account probable changes due to larger programs which I think you will all understand the Science Council will at least recommend.

If these larger programs come indeed into effect, they will absorb a greater number of Ph.D.'s than is represented on the data presented by Dr. Schneider.

Another effect that is slowly coming into play, but it will not be felt really for another four or five years, it is already at play in my own industry, is that industry will take up more Ph.D's, but not in the rather naive way that some people might misunderstand me, that the Ph.D will arrive green with a degree and will immediately move into let us say, production; that would be a misuse of talents.

What is happening is that Ph.D's with 10 years, 15 years of experience are moving into positions of managerial or supervisory capacity particularly in planning functions which fortunately is becoming more and more important in Canadian industry, operations, research, systems analysis, technological forecasting.

In our company we move them to control positions like chief metallurgists in our plants, chief chemists and you see in the lower ranks of the company a greater number of Ph.D's. They are leaving the research and development section and going to those, production you might say, and other functions, financing, marketing and sales.

They are, of course replaced at the R & D level by new recruits. I believe that in this way our management eventually, but this of course is a prediction over a period of 5 to 10 years, will be upgrading in a very real way in this fashion and management will need to be upgraded, gentlemen, because the pressures are already there. You see the fantastic complexity of making a managerial decision; the inability to evaluate; first of all the inability of establishing good criteria to start with by which we can judge the priorities which have been mentioned.

Well, all this more and more will be done over the next 10 years by methods of mathematical and numerical analysis, eventually performed on computers. The signs are already on the wall; the are called managerial decisions, operations research, systems analysis; technological forecasts, but those methods are coming to the fore and in order to use them wisely the management in our industries in Canada will have to be upgraded and I firmly believe that more and more Ph.D's will be used for that function.

Thank you, Mr. Chairman.

The Chairman: Can I ask a supplementary, too?

Dr. Schneider: Yes.

The Chairman: I was really surprised when I saw these forecasts for Canada in so far as engineers and scientists are concerned, because I was reading a few weeks ago an article by Dr. John Weir of the United States, who is Associate Professor of Psychology at California Institute of Technology. This appeared in this book entitled *The Next 90 Years*, and he makes some forecasts as far as the United States are concerned and there we can see quite clearly by this graph that the supply is going to be far short of the demand in the United States, resulting in a developing scarcity in the United States for such talents and skills and since in most fields we in Canada tend to follow the United States by about 8 to 10 years it seems to me that the same trend is going to develop in Canada;

that is why I was really surprised to see your gloomy forecast.

Dr. Schneider: I am sorry, I should correct that; I am not giving a gloomy forecast and I think I want to be very emphatic about this. The numbers we have presented are ones that have come out of a recent study.

Now, over a short term there may be some variations in it; also I think one has to take this along with the qualifications as I have indicated, but certainly over a longer term period I think the forecast you mentioned will certainly be true.

Senator Bourget: Would it be true in Canada, also?

Dr. Schneider: I expect so, yes. There are a lot of new areas developing, new disciplines and so on and, as I say, there will probably be continuing shortages in various areas.

We have seen this, for example, in the computer technology field; we still have a big shortage here and you will have these variations.

Now, that does not mean that in any one discipline from time to time you may not get a surplus of people but I am sure they are versatile enough that they will be absorbed somewhere, perhaps as I indicated even if it is high school teaching.

The other thing that should be mentioned, I think this has to be borne in mind too, is that one has to also look at the undergraduate enrolment in the sciences relative to the total student population, let us say, and if one looks at this certainly one can see that, and I think this is happening in other countries as well, the number of undergraduate students electing the science disciplines is certainly not increasing; if anything it may be decreasing. So I think one has to keep all of these factors in view.

Certainly I hope I didn't give the impression that this was a gloomy picture as far as Ph.D training was concerned.

Senator Carter: Could I ask another supplementary on that?

The Chairman: This is a new technique.

Senator Carter: The Ph.D's that we are producing now in the various fields in which they specialize, how do they match up with the needs in these fields, with the requirements?

I mean, are we over producing biologists and not enough physicists, or are we just balancing each field with the requirements in that field?

Dr. Schneider: Up to the present time we have not had a problem; as you can see, we have even had a shortage. It is only after next year perhaps this may develop in a few areas, but I think they will be relatively few. Perhaps we may have too many nuclear physicists, I don't know, but up until the present time there have been more positions, particularly in the universities, than there were people available.

I would like to say again, that I consider these numbers indicate, if there seems to be a mismatch it is not because I think that the number of Ph.D's we are turning out is mismatched so much, but I think what should be happening, particularly in the industrial research area, is not happening; this was really the main point of this Chart.

I rather think of this as an opportunity, having these highly trained people available, I think the big problem we have to face is to make sure they are now put to good use.

The Chairman: But it seems to me that from now on you will have to plan your graduate training program much more than in the past.

I was somewhat surprised to see in your brief, for instance, that on page 10 you say that these forecasts and analyses are based only on preliminary studies that you have made.

Well, as far as I know the Council has been in this field of training for a long time and I am surprised to realize that for all those years there was no truly serious study of the market and of the future demands.

Dr. Schneider: Well, perhaps in answer to that I should say we have not done it in quite as much detail as we are doing it now; it has been done in the past, but this is the most recent study we are doing, which we hope will be published within a few months.

I quite agree with you and the point of publishing this is that I think this is very valuable information for the universities, for students, as well as ourselves. And I think these statistics, the manpower situation we have to be aware of. From the point of view of the student, he wouldn't likely want to go into an area where he thinks there might not be very good opportunities.

So I think, if not planning, certainly I think this is information that should be widely known and I think there will be some response.

I don't think that the Council would ever try to impose some kind of quota, or anything like this on students, because after all this is a university function, training people, but I am sure that if the situation were accurately known I think there are enough built in checks and responses that the situation would take care of itself.

The Chairman: Well, surely you would at that time tend to review your scholarship program.

Senator Cameron: This discussion that has been going on is really directed to the training of scientific manpower and its utilization.

The question I want to have in mind, this goes back to our terms of reference in this Committee, to evolve a science policy for Canada. Here we have the universities playing a major role in training this scientific manpower. They are under provincial jurisdiction; in other words, they have a council and I am sure my friend Senator MacKenzie will agree with me that we should recognize that within universities there are intra-university politics. It depends on how effective the Dean of Engineering or the head of the botany department may be within the university in selling his program and getting his share of the resources to develop his own particular department; the reason for this is that he gets more elaborate facilities, and so on.

So we have on the one hand with every university one is duplicating what the others are doing. I think this is very graphically illustrated by your statements here about there being comparatively little in the Maritimes vis-a-vis the other parts of Canada.

All right, is it not necessary for the National Research Council, the Science Council, the Science Secretariat and the universities to evolve an overall program in which they present a coordinated front and analyze the very thing we are talking about here: What are the anticipated needs in the next few years and who is going to meet them?

That is relatively simple on the face of it, but it has a very direct bearing on where students will go from graduate work. If I was a student going to graduate work, I wouldn't go to an institution which might have a Nobel Prize person heading this particular department; if they only had this one man and a few satellites around him, because the value of his study would be to the extent that he has the opportunity to associate and explore with many scientific minds.

In other words, you need strength in depth in each department and you see a classic illustration of that in the aeronautical space work at Toronto, the Neurological Institute at Montreal, and we have been doing a fair amount of engineering in Alberta.

In other words, it comes down to this, that should not there be much more strength and specialization at certain universities where most of the work in a particular field will be done, which means that the province is not going to do it. Now, it seems to me, and I could be wrong in this, that there has not been sufficient co-ordination between all of these bodies and it seems to me that one of the responsibilities of this Committee is to come up with some recommendations as to how the full resources, our full scientific resources can be mobilized most effectively as a national effort, rather than as an effort of the National Research Council, the University of Toronto, or something like that.

Now, how can this be done?

Dr. Schneider: Certainly I think up until fairly recently all of these things have not been problems; we were so short of people that the more we could get trained the better.

A lot of new universities were started and I think it is only now that we have to start to face up to these problems and I can assure you that all the universities are thinking very hard about this. They recognize the problem and, as you know, also in some of the provinces, notably in Ontario where there is a provincial university committee trying to consider exactly these kinds of problems, how we can avoid overlap between universities and how we can specialize to get this depth and concentration in certain areas. To build the kind of excellence that we hope to build, I think we must have depth and concentration; we cannot do it if we spread ourselves too thin and every university trying to do the same thing.

This is well recognized by universities; it is well recognized by our Council; we are trying to work together with the universities to encourage this, but perhaps Professor Bonneau would like to add some comment to this.

[*Translation*]

Professor Bonneau: Perhaps I might simply say that, in the Province of Quebec as well, this type of problem between universities has arisen and is being resolved similarly to what has been done in Ontario. In the sense of a co-ordination of total research effort, each Ontario university attempts to find the spot where it would be most useful to the regional group. Personally, I feel that such concerted action should be on a regional rather than a provincial level. I am thinking particularly of the Atlantic provinces where the concentration of effort, at least according to what is said down there, appears to be on a regional rather than a provincial scale.

Perhaps there are other areas in Canada where action might be taken on a regional basis. In any event, this effort towards concentration should be made at all levels of university activities even if, at present, we do have a government agency concerned with research and development.

[*English*]

The Chairman: I am told that coffee is served.

Senator Bourget: Before coffee is served, would you have any objection to Dr. Bonneau answering my question?

The Chairman: No, proceed.

[*Translation*]

Professor Bonneau: Mr. Chairman, I should like to reply to Senator Bourget by quoting the following figures as pursuant to our discussion: in 1973, approximately 20 percent of the total number of Ph.D degrees will be awarded in engineering and 80 percent in the sciences.

Senator Bourget: What is the reason for this trend, for the fact that engineers, or rather Ph.D's, are found in research and physics rather than in engineering? Is there a particular reason for this? Is it due to the fact that they perhaps receive less money? Or is there a movement in favour of this branch?

Professor Bonneau: Mr. Chairman, I feel we need a little time to expand on this matter.

Senator Bourget: The reason why I asked the question—and to return to what Dr. Gauvin said—is that the senators are interested in seeing whether there would not be a way of improving the situation with regard to practical research so that we might attain the objectives for which the National Research Council was formed in the beginning. It suggests to me—Dr. Schneider mentioned the fact and I was also able to read similar comments in other publications, the Engineers' Institute, the Glassco report—that little has been done in this respect. I do not want to put the blame on anyone. It seems to me, from the point of view of the economic interest of our country, that the emphasis should now be placed on this part of research which would bring dollars and cents, let's put it bluntly, to the country. I feel it is necessary that we have pure research as it is very important; it is the basis, but, on the other hand, I feel we must not forget the other aspect, the material interest, if you will.

The Chairman: I shall give two minutes to Dr. Bonneau.

Professor Bonneau: Thank you, Mr. Chairman. The question does, indeed, merit development and this would take some time. I shall try to be brief but I shall not do justice to the question.

At present, in the universities, applied research tends to be set aside for what might be called pure research for a very simple reason: that is, the link between industry and the university is still extremely small and, in certain cases, nonexistent so that a research worker in mechanical or civil engineering will have considerable freedom in his research. It is not easy to lead the student to the construction site with that, but given this freedom in applied research, we are able to make better use of the materials we have, even if our work is not related to engineering. If it is not related to engineering, it would still be basic research but in a field which is applied. This is, I believe, the reason why some applied research is carried out everywhere.

We are not an industrial country. There are whole areas in which the universities do applied research for nonexistent industries with the result that the projects are too impractical. Herein lies the tragedy, I feel, if we want to call it that.

Finally, the problem in Canada is that there are very few industries as compared to the industrial countries—I mention Sweden. In Sweden there is an extremely close link between the industries and the universities and these problems assume a very different form.

Another fundamental reason, very often, is that engineering requires much more money and this poses a basic problem from the economic point of view at present for certain companies. There is a need, in Canada, to conduct research on transportation, but don't try to undertake valid projects on transportation in a university laboratory; this does not mean that university professors are not qualified to conduct such studies, but they require much more team work, the building of a prototype which is extremely cumbersome. At the present time, this work is not really within the scope of the universities.

Senator Bourget: Just a word, Mr. Chairman. I feel it is an extremely interesting question—not just because I raised it—but because Dr. Bonneau said that it was almost a tragedy. Indeed, I believe it is a tragedy that there is this kind of apathy on the part of industry, as we discussed this morning. I do not know why this is. I wonder if there is enough contact between the research branch, or the National Research Council, the universities and industry. Do discussions take place? Are there meetings? Do we want to interest industry as I believe businessmen are interested in development as Dr. Bonneau mentioned this morning—and he quoted two examples. It seems to me that Canadian industry should have eagerly grasped at the opportunity. I wonder why this apathy exists? It is perhaps not up to you to answer this question for me but I feel that there is perhaps some lack of liaison, or is it because industries feel they are not adequately assisted financially? Or is it because research is concentrated in the area of pure research and not enough in the field of applied research? This leads me to another point that, according to what I read in the Glassco Commission report, of the 21 members—please note that I do not wish to criticize any member of the National Research Council—but of the 21 members of the Council, only three are from industry, according to what I read, and there is not a single economist. I wonder whether it would not be appropriate to make a few changes in this respect? I believe that Dr. Schneider is proposing himself to make changes in this regard. Now the reason I am asking these questions is because, returning to the words of Dr. Bonneau, it is a tragedy that not enough importance is being given to research and I wonder what is being done to assist our home industries.

[*English*]

—A short recess.

(*Upon resuming*)

The Chairman: Honourable senators, we still have about three quarters of an hour before dinner and I am sure that there are still a lot of questions, so we may have to think whether or not we shall continue to sit this evening, or whether we should invite the Council at another date to come back before us.

I don't want to make any proposal at this time, but I want you to think about this when you select your questions during the next three quarters of an hour. Senator MacKenzie.

Senator MacKenzie: I just wanted to make a comment, Mr. Chairman, because the Atlantic provinces have been mentioned in terms of research or lack of research that is being done in that area.

Now, I happen to know something about three of the provinces, in particular, Nova Scotia where I have been Chairman of their University Grants Committee for the past six years, and New Brunswick and Prince Edward Island, and the fact of the matter is that they have not got enough money in the revenues of their provinces to compete in any effective way.

The Chairman: Like the British Columbia universities.

Senator MacKenzie: Well, they are a little different in British Columbia; I can give you a song and dance about that, but those in the Atlantic provinces—

There has been a good deal of cooperation, rationalization, or whatever you like in the Atlantic provinces and in Nova Scotia I know that practically all of the professional school work and the high level research and graduate work that is at the Ph.D level is concentrated in one institution and something of the same is done in New Brunswick at the University of New Brunswick, though the University of Moncton I know has a program.

The Chairman: Well, I am sure, Senator Mackenzie, that when we come to the third phase of our inquiry we will hear from universities.

Senator MacKenzie: But I just wanted to throw that in at this point, sir; I don't want to elaborate on it. That is a fact.

The Chairman: I am sure that you will see to it that they will present a brief to us.

Senator MacKenzie: I hope they will.

The Chairman: Senator Grosart.

Senator Grosart: I would like to drop down a bit from the Ph.D level to more mundane things. There is one question that occurs to me on that level, how valid is the Ph.D; has Ph.D productivity significance? How valid is it as an index of the scientific manpower requirements?

I have seen some literature which suggests that B.Sc.'s or M.Sc.'s or MA's, certainly in the industrial sector, the production in this area might be a more important index.

Dr. Schneider: I think that is a very good point and I had hoped that we won't lose sight of this simply because we happened to put some numbers before you which applied to Ph.D's.

Certainly it is quite true that in any, and particularly in applied research, perhaps more so than in basic research, you also require people at M.Sc. and B.Sc. level, and a lot of these, of course, if they go in at a B.Sc. or M.Sc. level and work in a research laboratory in industry, what they learn on the job after so many years would be equivalent to a Ph.D.

Not all of them will advance this way and in fact I expect that the present distribution, particularly in industry, probably for every Ph.D there will be a certain number of B.Sc's and M.Sc's.

In the more basic sciences, or longer range applied research you will probably find that you do use a lot more Ph.D's, because you do require people with research training.

There is another trend that has come about; with the emergence of very good technical schools and community colleges we are now producing in this country some highly qualified technicians and a lot of these are now taking over the kind of thing that a B.Sc. graduate would have done in the past.

I might say most of these people are very well trained in various specialties in the sciences, but certainly there is a place for the B.Sc. and the M.Sc. and probably they would still be used in larger numbers than Ph.D's.

But I think in the more sophisticated research programs, I think any laboratory recruiting a research trained man would go for a Ph.D. In fact, in the universities now the Ph.D. is a sort of minimum; certainly in most of the other disciplines. The Ph.D. also is now required to get a staff appointment at a Canadian university; you probably must have in addition to your Ph.D. several years of postdoctoral training.

So this has moved ahead further than perhaps ten years ago.

Senator Grosart: You do have a program in that field, do you?

Dr. Schneider: We have a program of postdoctoral fellows at our laboratories and also there is an extensive program in the universities, too.

Postdoctoral fellows, now this is if you like, a sort of post Ph.D. training and, as I say, it is almost mandatory in certain disciplines.

Senator Grosart: Now, if I may come back again to the role of the NRC in future, which as Senator Cameron points out is something on which we are expected to report, it seems to me that the Council has moved in to fill a gap in this educational field where you are now spending $51 million in the university R & D support.

Could you tell me what percentage that is of the total amount available to the universities in this field? How much of the gap are you filling there?

Dr. Schneider: I think we have some numbers on this as a result of this study

You see, our research grants are really grants in aid; they are not intended to pay the whole cost, because the basic idea here is that the university should have control of their own programs; we will insist that they must keep control and the university contributes a good deal.

The percentage let us say of the total and this includes all the costs to the university and so on, perhaps Professor Bonneau has some figures?

Professor Bonneau: Yes, Mr. Chairman; I have some figures here that pertain to university requirements for research in major equipment and major installations.

In 1968 NRC funds supplied roughly 32 per cent; the university funds supplied 55 per cent roughly; the rest is everything else.

Senator Grosart: Yes, there is a big gap there.

Dr. Schneider: Well, these are funds that come from other agencies; they could be federal government agencies, foundations and so on.

Professor Bonneau: Foundations.

Senator Grosart: We hear the figure given that the federal government is contributing 50% of the total cost of all post secondary school education.

I presume that would take in the grants as well, so it would seem to me that your proportion of $51 million then is a very large part of the federal government's contribution to university R&D.

The other figure takes in all university costs, not just R&D. I am trying to find out how much of this gap the NRC is filling in what appears to me to be almost a gratuitous assumption of a responsibility.

If we were to check this criticism, if you like to call it that, by the Glassco Commission and the Engineering Institute that you have gone away from your terms of reference; I am not saying that I agree with it, but this is what they have said, that if you read your terms of reference in the Act in Section 13, they interpret this as saying you should be putting nearly all your money into industrial research and that is why I say this may be a gratuitous assumption of a responsibility.

This is what concerns me in the policy field: Is this government policy, can you call this government policy when you step in and say, here is a gap and we are going to fill it?

Dr. Schneider: Perhaps I could best answer that by going back a bit to when the Research Council was first established.

You are quite right in saying that in our Act there is certainly no mention of this kind of a program. When the Council was first established and they were supposed to undertake and support and coordinate research, they found that there were just so few trained research people in the country that the very first thing that they had to do was provide for training for research.

This is how this program got started, way back in 1917, or 1918, and it has continued.

Now, as I understand it, the discussions of the federal government with the provinces was that there was mutual agreement that the federal government has a responsibility, in the research area. This, of course, does not make this a statutory responsibility as far as NRC is concerned, but at least I suppose it is fair to say that this is being done with the full agreement of the provinces.

I think that as far as the total funds are concerned, you mentioned something like $51 million in research grants, my guess would be that this is still quite a lot less than the ordinary operating funds, but, of course, this only goes to support the specific research area and would presumably not be covered under the ordinary operating funds of which the federal government provides half through fiscal transfer.

Senator Grosart: Then I am still on this question of where the decision is made: Would it be fair then to say that this gap exists, and I am not in any way criticizing your move into the gap, but would it be fair to say that the NRC saw this gap and persuaded the government or the governments that the way to fill it was to have NRC provide in this year $51 million?

Senator MacKenzie: Mr. Chairman, could I interject a comment here, because as I understand it what the NRC is doing in the universities in the main is supporting research and that is its function; not supporting the universities and not doing what you suggest it is doing, filling a gap. It is concerned with the promotion of research in Canada and it has found the easiest, best and most efficient vehicle through which to do it for certain purposes is the university and if you want NRC to recreate here and across Canada, if you like other research intitutions in which this work can be done, this can be done at a cost to the taxpayer and the federal government.

Senator Grosart: Senator, I am only asking questions.

Senator MacKenzie: But they are loaded questions.

Senator Grosart: I am not attempting to provide any answers; this will be a responsibility of the Committee at some time, and I shudder to think how we are going to handle it.

Could I ask another question, just again to try to put the function and responsibility of NRC in some kind of focus: We have a figure of 1.3% GNP is the total Canadian expenditure on R & D. If my arithmetic is correct, that is about $800 million. Your share,

the share that you have assumed, is $120 million, leaving out the Medical Research Council. Where does the rest come from? First of all, how much of the rest comes from government; in other words, I want to get the percentage of the total government financial support of R & D that comes through NRC? Is that figure available?

Dr. Schneider: I think these figures are available, but I don't have them with me. I think the figure $800 million sounds a bit high; it is around $600 million and this, of course, includes all federal agencies, such as AECL, Aiculture, Fisheries, Forestry, all federal government funds for research; it includes a number of big departments and other agencies.

Senator Grosart: But this 1.3 would also include industries, wouldn't it?

The Chairman: Yes; you get most of this information in John Orr's study. I think you have a copy of it.

Senator Grosart: I have, and I have looked at it.

Professor Bonneau: I might speak on one answer, Mr. Chairman: In 67-68, industry will be spending or has spent $300 million; universities, $190 million; and government, $240 million.

Senator Bourget: What is the figure again, Professor Bonneau?

Professor Bonneau: $300 millions. $190 millions pour les universités et $240 millions pour tous les gouvernements—pas le gouvernement fédéral, mais tous les gouvernements.

Senator Grosart: Yes, it was 730 million.

Professor Bonneau: Yes.

Dr. Hunt: Mr. Chairman, may I interrupt: That I think is not the funds supplied; that is where the funds were used.

Professor Bonneau: Yes, current operating.

Senator Grosart: Not where the funds came from?

Dr. Hunt: No, no.

The Chairman: This is the sector of performance.

Senator Grosart: Yes, that is the performance figures.

Dr. Hunt: And your $800 million, I think it is fairly close, Senator, that includes capital.

If you add the capital expenditures it is very close to $800 million.

Senator Grosart: What percentage of this is supplied by the federal government; that is what I am trying to get at?

The NRC is trying, one way or another, to fill this gap and if Senator Mackenzie will allow me...

Senator MacKenzie: I won't, but you will.

Senator Grosart: In my theory and personal experience it is a gap.

Dr. Hunt: Senator and Mr. Chairman: I have not the actual figures of the $300 million that Professor Bonneau mentioned on industry; a quite large proportion of it, though, is industry itself, very little is government. It is in the neighbourhood I think of about 75 per cent industry; I have not the actual numbers.

Senator Grosart: And this includes the 6 million from the NRC which is, of course, a very small part.

Dr. Hunt: Yes.

Senator Grosart: Again, I am trying to see what is the responsibility at the moment, the financial responsibility undertaken by or satisfied through NRC, as a general way of stating it.

What percentage of the total government expenditure? Do we have that figure?

Dr. Schneider: The total government expenditure, this is available on science. It seems to me this is around $600 million, or a little higher.

Let us be clear that we are talking about the same numbers and which fiscal year; this is 1967, 68.

Professor Bonneau: 1967, 68; I think $240 million of those and just current operating R and D costs. I don't think that you have capital costs included, for instance.

Dr. Hunt: Mr. Chairman, may I interrupt again. These figures are all available through DBS; I am sorry, I use them a great deal but I have not got them at my fingertips. They are separate reports issued on industry and government expenditure.

The Chairman: The latest figures are available but they are not, I think, here; they deal

only with the intra-mural research done by the federal government and for the fiscal year 66, 67 they amounted to $200 million.

Senator Grosart: Now, by intra-mural, does this mean inter-departmental?

Dr. Hunt: In house.

Senator Grosart: Yes, but the federal house is a big one. Does this include Crown corporations; does it include NRC?

The Chairman: Oh, yes.

Senator Grosart: Well, if it is $200 million and NRC is $120 million.

Dr. Schneider: No, $45 million.

The Chairman: In 66, 67 NRC spent $37.4 million out of $200 million for in-house research.

Senator Grosart: Oh, I see; yes, I get the distinction.

But what I am trying to get at is what is the total demand on the public purse for R & D, the federal public purse?

The Chairman: I am quite sure, Senator, that if you don't want it in too great a hurry that our staff can provide these figures for you.

Senator Grosart: Yes; well, the reason I was looking for it now is I am still trying to fix how great is the responsibility that NRC has undertaken.

This to me is a very, very important question when we are going to assess the future policy of the government in respect to NRC.

Dr. Schneider: Well, as far as the in-house research is concerned here, I think we have to distinguish this from extra-mural research support.

In house as we heard the figures is 37 out of about 200 million; it is between a fifth and a sixth of the total federal government in house research expenditures.

Senator Grosart: Yes, this would only apply to 37 million of your expenditures, yes.

Dr. Schneider, in an article you wrote for the *Science Forum* you make this very interesting statement:

> "Accordingly a review and re-appraisal of the Council's programs and policies is now opportune and necessary. A useful principle here is that those programs and policies that have been very successful and for which there is a continuing need should not be tampered with too much; those that have been less successful or lacking need detailed study."

Have you any method, critical path or anything like that, by which you assess success, or more or less success?

Dr. Schneider: As I mentioned, I think it was this morning, this is now getting under way. We have set up a group headed by Dr. Cook, which we call a délégué général, with a staff, to go into this in detail.

I might mention that this group has no other operating responsibilities; they will spend full time on this and we hope to look at these programs in detail.

The reason I think it is opportune is because things have changed very rapidly, as we have seen from some of the data we have presented to you. I think there have to be rapid changes; things are moving very rapidly, and we have to look at what we have been doing and certainly there will have to be some decisions made about where we are going and how we should plan for the future.

Senator Grosart: This was one of the questions that was specifically asked in the guide lines and when I went to compare your brief with the guide lines I notice I wrote in the margin, no comments given.

There are one or two others, and because we are going to have a good many other departments before us I wonder if you would not misunderstand this question: If there was a failure of response to the specific questions asked in the guide lines, if there was, was it accidental or deliberate?

Dr. Schneider: Perhaps a bit...

Senator Grosart: I say if there was.

Dr. Schneider: Perhaps a bit of both, and I think we did discuss this with Dr. Poecock, because we understood that this questionnaire, if we can call it that, was of course prepared to apply to everybody and we felt in some of the areas it wasn't particularly applicable.

At this particular point we should have said something in it; that I think was an accidental omission. So that, as I say, there was perhaps a bit of both, but the intent was certainly to provide you with all the information; there was certainly no deliberate

attempt to fail to respond to any pertinent information.

Senator Grosart: No, I don't doubt that at all; I was merely assessing our own questionnaire, because a good deal of time was spent on it and it does project into the future as to the general validity of this questionnaire with respect to those who will come before us.

Professor Bonneau: Could I enlarge a bit on the feed back mechanism, that you asked whether it existed in that there is a review of all the progress which is going on. The President has just explained that a new post with a staff has been set up and will be operating, but there has been for many years another system, which is working well in many instances, and those are advisory committees.

For instance, in the building industry you have architects, you have engineers, you have building contractors, you have people from the Central Mortgage; all these people get together and review quite frankly and quite critically once or twice a year, or sometimes more often the work of a division on the committee for the mechanical engineering division there is a man from the shipping industry, another one from the railway industry, another from the aircraft industry etc. They get together, and they work quite hard. They ask very difficult questions of the director of the division on the existing programs, what are the results, and other relevant questions.

I don't want to give you the impression that all those advisory committees are equal in ther tasks, but some of them are doing very good work and I think that the division which profits by the work of that committee is quite lucky, because it does keep that division on their toes.

Senator Grosart: I think we are all agreed that it is very hard to stop any project anywhere in the general realm of the public service once it has started and, secondly, I think we are all aware that it is very difficult at any particular time to assess the continuing validity of a research program but, having said that, could you venture a guess as to the percentage of termination of projects as a result of these reviews that have been going on, or is this question germane at all? I don't know.

Dr. Schneider: If you are talking about major programs and, of course, research is not something that you can turn on and off; it takes time to build up a research team and then by the time they really get hold of the problem and something comes out it may be another five years.

Senator Grosart: Excuse me, but sometimes when they are turned off they are on the front pages for a long time.

Dr. Schneider: Yes, but of course with the smaller projects, these come and go; there is quite a large turnover but let us say for example, as we have mentioned before, the National Aeronautical Establishment, which provides back-up research for the aircraft industry; now, that is a continuing, if you like, activity but yet there are individual projects that come and go; projects are completed, a new one is started, and so on.

So I think some of these methods, review methods that you have referred to, are not always applicable to some of these individual activities.

The Chairman: Senator Yuzyk has been waiting for hours.

Senator Yuzyk: My question is about the researchers, particularly the National Research Council and I have before me a review in 1968 and I note that there are 788 scientists employed by the National Research Council: 264 in engineering and architecture; 221, these are the largest, in chemistry; 189 in mathematics and in physics.

My question is this: Has the staff of the National Research Council been increasing every year, annually? One thing.

How much of this staff is permanent and how many of them are non-permanent? I am particularly interested in the non-permanent staff, that is employed for research work. What happens to those who are employed for a period of one or two or whatever period they are employed for, what happens to these scientists? That is another question.

The Chairman: Could you break it down?

Senator Yuzyk: Am I asking too many?

The Chairman: Yes, I think so.

Senator Yuzyk: Well, it is all in the same line.

I notice a large category and I don't know how many of them there are in this category, post doctorate fellows. Now, there are quite a number of them and a large proportion of

them are out of Canada, I noticed that. What happens to what I call the non-permanent staff; what happens to these people? Are they employed by industry in Canada or by universities once they leave the National Research Council?

Dr. Tupper: Mr. Chairman, I will endeavour to field this question; let us start the wrong way around, with the Post-doctorate Fellows.

This is a program designed by Dr. Schneider's predecessor once removed, Dr. Steacie, shortly after the war, to accomplish two purposes, the first to provide a core of young, energetic scientists who wouldn't grow old on the job so that you would have a definite fraction of youth continuously in your spectrum, even though you were not growing or had not reached a steady state where people were retiring at one end and coming in at the other. These men are given a small stipend; currently it is $6,000 a year for a single man and $7,200 for a married man, which is income tax free. The normal appointment is for one year and it may be renewed for a second and thereafter they disappear from our establishment, except that we occasionally take one of them om to our regular staff. So much for Post-doctorate Fellows.

Of the remainder of the staff, the National Research Council is perhaps unique in hiring a large fraction of its employees using term appointments. The original term is usually for one year or for 18 months and if the employee's services are satisfactory subsequent term appointments are for three years.

I think at the present time we probably have about 80 per cent of our total staff on three year term appointment.

There is, however, the circumstance that since the end of the second world war, while there have been a few periods of time when there was a shrinkage, by and large the strength and size of the National Research Council has grown with time; it has indeed spawned whole organizations like the Crown company, Atomic Energy of Canada Limited, which up until about 1952 or thereabouts was a portion of the National Research Council.

So that, although we have many three-year term appointees, there has been no cut-back in work of a major nature that has required us to release these people because their jobs have disappeared. Term appointees may be let go because their services are found to be unsatisfactory, of which they are given plenty of warning before such termination actually takes place. I think it is perhaps unreasonably assumed by our staff that an NRC term appointment is just as secure as an appointment "at pleasure," although from the strict documentary facts of the case this is not so; it is a three-year appointment, and unless it is renewed it would terminate.

Senator Yuzyk: Is there an attempt made to place these researchers after they have completed their term? After they have completed their project or whatever they have been working on what hapens?

I am particularly interested in those who are non-permanent; what happens to these scientists, where do they go?

Dr. Tupper: Mr. Chairman, to avoid any possible misunderstanding, the PDF'S are with us for one or two years and then they are released. In the market that has existed during the last few years one did not have to assist in placing the PDF's; there has been more demand for persons with doctors' degrees in universities and elsewhere than there was supply, so there has been no problem of this kind.

With the employees of our Council generally who have the three-year term appointment. These appointments have normally been renewed. These employees are not with us just three years and then out. They have normally had continuing employment through term appointments which were renewed every three years.

Senator Yuzyk: A supplementary question please, regarding bachelors; I notice that there are bachelors, 140; masters, 165; and doctors, 493. Are these with Bachelor of Science degree, I imagine mainly: Are they employed for just a term, or are some of them permanent also?

Dr. Tupper: Mr. Chairman, there is no simple quick answer to that; in some of our laboratories the work is of an applied nature and we hire engineers as well as physicists, chemists, biologists. Many of the engineers have only bachelors or masters degrees and do not have doctors degrees. The doctor's degree in engineering until fairly recent times was quite uncommon, so that to some extent that division by degrees is also a division by discipline in that the 140 I think would be quite predominantly engineers rather than physicists, mathematicians or chemists.

Senator Grosart: Mr. Chairman, a supplementary question: Would Dr. Tupper relate his answer to Appendix L to give us a summary of Appendix L, which is headed, Former Scientific and Engineering Staff Who Now Hold Significant Positions in Other Areas of Activity.

This obviously does not apply only to part time employees, but to me it is a very impressive appendix.

Dr. Tupper: Yes, Mr. Chairman; although we have three year term appointments I would think that in general we have had many people who have come to the Council, worked there for X or Y years and X or Y might be three or fifteen and then have moved on to other positions; they have gone into the universities, they have gone into industry, they have gone into other places.

I myself was one of these; I was outside the National Research Council for a 15 year period. Mr. Pocock, one of your staff here, was one of these. There are many people who have served with us. I like to use the word "alumni", for these people are mostly employees who have left of their own accord and not just because their term was up. They have moved on to many other places.

This is but a partial list. Naturally it is a loaded list. We have picked from those who perhaps have made more of a mark than others, but it is a very incomplete one.

There is a normal turnover rate of about 6% with our scientific staff, and since we have about 800 this means that there are about 50 a year leaving naturally. As a consequence, over a twenty- or thirty-year period, we have collected quite an alumni association.

The Chairman: Senator Carter.

Senator Carter: I would like to follow up with a supplementary: Dr. Schneider mentioned the importance of technicians and that we are getting now very highly trained technicians, who could take over very advanced work.

I think I read somewhere that a scientist who is directing a project needs at least four good technicians to be able to produce satisfactorily. I am just wondering how is the NRC fixed for technicians? What ratio do you have, or do you have a ratio, do you employ them on a ratio basis? Are these technicians under contract to the Council, or are they full time?

Dr. Schneider: No, we don't employ them on any kind of formula, but solely in response to need.

The number of technicians working, say, with each research scientist will vary depending on the nature of the work. For example, someone who is doing mainly theoretical work perhaps wants somebody to help with some computational work and that is about all.

On the other hand, in the applied sciences and particularly in engineering, where you have a big facility, you are operating a wind tunnel, let us say, you need quite a number of technicians to keep this going, so it varies depending on the kind of work.

Now, as for actual statistics, it varies from about .68 technicians per scientist to about 4.33; this is going, let us say, from chemistry to mechanical engineering, which has, let us say, around 4 technicians per scientist. So it does vary.

The terms of employment are very similar; this is again on the term basis.

Senator Cameron: On behalf of the members of the Committee, I wish to express our very deep appreciation to the delegation for their appearance and courtesy in answering the very heavy barrage of questions. I feel it has been a very productive session.

The Chairman: I was going to do the same thing; thank you very much, gentlemen.

Dr. Schneider: Thank you very much.

APPENDIX 1

SENATE OF CANADA
SPECIAL COMMITTEE ON SCIENCE POLICY

GUIDE FOR SUBMISSION OF BRIEFS AND PARTICIPATION IN HEARINGS

TABLE OF CONTENTS

SENATE OF CANADA
SPECIAL COMMITTEE ON
SCIENCE POLICY

GUIDE FOR SUBMISSION OF BRIEFS AND PARTICIPATION IN HEARINGS

Introduction

Part I of this guide is for the assistance of all organizations or individuals intending to submit briefs. Part II describes information required from agencies of the Federal Government.

Part I: General Guidance

I. 1. *Contents of Submissions*

Briefs should deal with the subject matters which fall within the scope of inquiry of the Committee, as contained in the attached Order of Reference (Appendix A). This Order of Reference, and any other relevant material which may be made available by the Committee, should be carefully read before briefs are prepared.

To make submissions to the Committee as useful as possible and to facilitate the Committee in obtaining a full understanding of the views put forward and recommendations made, the following points should be borne in mind when preparing the briefs:

(a) Factual information should be included tending to substantiate the conclusions put forward, the views expressed and the claims made.

(b) Recommendations should be made as specific as possible, putting forward concrete proposals indicating whether and what action should be taken, what form the action should take, and how the proposal could be implemented in practice.

(c) The brief should be prefaced by a summary of the main conclusions and recommendations.

(d) Brevity is recommended in the main body of the submission. Those preparing briefs may, if desired, submit relevant evidence in appendix form.

(e) In the case of associations and organizations, the briefs should include information on the personnel, objectives and nature of the group.

I. 2. *Format of Submissions*

Briefs should be double spaced with consecutive paragraphs numbered, on foolscap (8″ x 14½). The name and address of the association, organization or person submitting the brief should be clearly indicated. Where organizations and individuals wish to appear at the hearings, the names and addresses of those who will represent the organizations or of the individuals should be stated.

The curriculum vitae of all those intending to participate in the presentation of the brief and the subsequent discussions must be attached to the brief.

I. 3. *Number of Copies of Submissions*

The Committee requires fifty (50) copies of each brief. It is suggested that copies in French be provided. Organizations and others submitting briefs may wish to have available additional copies which they can pass on to the press and other interested parties. Although each organization is responsible for the distribution of its brief, the Secretary will distribute it to the members of the Parliamentary Press Gallery upon receipt of an additional 95 English-language and 35 French-language copies.

I. 4. *Presentation of Submissions*

The full texts of the submissions, ordinarily will be taken as read. At the hearings, participants will be asked to summarize the information contained in their submissions as well as their conclusions and recommendations. They are free to elaborate orally and present arguments. Persons appearing before the Committee may be questioned directly by members of the Committee on the material submitted in their briefs and the recommendations put forward, but they will not be subject to examination or cross-examination by other persons.

I. 5. *Exhibits at Hearings*

Participants are permitted to introduce at the hearings supplementary information and material in written form. These will be known as exhibits.

I. 6. *Transcripts of Proceedings of Hearings*

The proceedings at the hearings held by the Committee will be recorded and printed. Copies may be purchased from the Queen's Printer. Reports of the Committee's proceedings are supplied at reduced rates when ordered immediately following the Committee

sitting. A limited number may be obtained without charge on application to the Secretary. (See I. 8. below)

I. 7. *Confidential Character of Submissions*

Submissions made to the Committee will remain confidential until released, the release date being the day on which the organization's representative appears as a witness. In the case of briefs supplied but not presented at the hearings, the release date will be at the discretion of the Chairman.

I. 8. *Contact with Senate Committees Branch*

Information concerning the activities of the Senate's Special Committee on Science Policy (e.g. proceedings of the hearings, etc.) may be obtained from

Patrick J. Savoie,
Secretary,
Room 369-E,
Committees Branch,
The Senate,
Ottawa, Ontario.
Telephone No. 996-1272

Also, all briefs and exhibits should be sent to *the Federal Government*

PART II: Specific guidance for agencies of the Federal Government

II. 1. *Introduction*

All departments, boards, crown corporations and other organizations (hereafter referred to as agencies) under the jurisdiction of the Federal Government are asked to submit briefs if they expend funds for scientific activities. Appendix B defines "scientific activities" and other terms.

II. 2. *Content of Submissions*

Briefs should contain any information, comments or counsel considered relevant to the inquiry of the Committee in view of the Committee's Order of Reference (attached as Appendix A). As well, the Committee requests information regardin the following:

2.1) *Organization*—Supply text or diagrams regarding the following:

a) Organizational block diagram of agency showing main units such as divisions and sections. Indicate those units conducting or funding scientific activities.

b) Block diagram, when appropriate or necessary, indicating Parliamentary reporting channel (s), formal connections to other Federal agencies, advisory committees, etc.

c) Block diagram indicating the organization of units (e.g. divisions, sections, task forces, etc.) responsible for scientific activities.

d) Description of formal agreements regarding scientific activities between agency (or one of its units) with organizations outside of Canada including foreign governments or their agencies.

e) Information concerning overseas offices of agency dealing with scientific affairs.

2.2) *Organizational functions*

a) What are the agency's statutory functions and powers regarding scientific activities.

b) What organizational policies have evolved (e.g. regarding the implementation of (a)) that could be considered to define your agency's "policy regarding science" or "science policy".

c) Taking (a)) and (b)) into account, briefly describe the organization's functions and responsibilities in relation to:

i) other Federal agencies
ii) industry
iii) educational institutions
iv) international representation and the monitoring of scientific activities outside of Canada
v) other

and describe the process whereby these are achieved or honoured, citing cases-in-point if appropriate or necessary.

d) Describe the process whereby your operational effectiveness, duties and goals are reviewed and revised.

e) Describe any outside studies commissioned (during the last five years) to suggest improvements of agency's operating procedures.

f) Comment on the relationship between the agency's responsibilities and powers, and its activities and programmes.

g) What have been, what are currently, and what do you foresee as being the major hindrances to the effective performance of your functions, the honouring of your responsibilities and powers.

h) What major changes in organization functions are forecast as probable or desirable during the next five years.

(2.3) *Personnel Policies*

a) What steps are taken to identify and hire those members of universty graduating classes who will be the most effective researchers for your organization.

b) Have any unique criteria been developed (or any research initiated to develop criteria) to help identify those who will be creative and effective researchers.

c) What steps are taken to identify those members of the staff with high potentiality as research administrators.

d) What distinctions are made between administrators of research and researchers as such; for example, regarding promotion, salaries, etc.

e) What is the policy regarding intramural and extramural education for staff members conducting or administering research.

2.4) *Distribution of activities*

Some agencies expend funds on scientific activities in many regions of Canada. These are requested to give information and advice regarding the following:

a) The regionsl pattern of agency's spending (intramural and extramural) on scientific activities (e.g. by province).

b) The regions, if any, particularly suited for certain scientific activities.

c) Activities carried out, on an annual basis during the last five years, to assist in the investigation of regional problems of phenomena.

d) The role of your agency in contributing to regional development.

e) In your experience, the cost and benefits of regional distrbution of your scientific activities and the necessary conditions for this distribution to contribute to regional development.

2.5 *Personnel associated with scientific activities*

Note that the following information is required for each of the units conducting scientific activities mentioned in Section 2.1) c).

a) Current personnel establishment and people on strength by category of personnel. (Indicate the number of guest workers, staff-on-loan, post-doctorate fellows, etc.)

b) Number of above professional staff devoting most of their time to administrative duties.

c) Tabulated information regarding professional staff associated with scientific activities (divided into three categories according to degree level—i.e. bachelor, master, doctorate).

i) Country of birth

ii) Country in which secondary education taken

iii) Country in which university degree taken (bachelor, master, doctorate)

iv) Number of working years since graduation and number of years employed in present organization

v) Average age

vi) Percentage able to operate effectively in Canada's two official languages

d) Total number of professional staff in each degree category for each of the years 1962 to 1968 inclusive and estimates for each of the years 1969 to 1973.

e) Percentage of turnover of professional staff in the three degree categories for each of the years 1962 to 1967.

f) Percentage of current professional personnel who, since graduation, (i) have been employed by industry at one time, (ii) have been on the staff of universities, (iii) provincial departments or agencies, or (iv) other Federal agencies.

g) Number of staff in each degree category on education leave.

h) Number of university students given summer employment in the field of scientific activities for the years 1962 to 1967.

2.6) *Expenditures associated with scientific activities*

Where appropriate, please use definitions given in Appendix B.

a) Total funds spent by agency on scientific activities broken down into the following categories:

Functions: (i) intramural R&D, (2) data collection, (3) scientific information, (4) testing and standardization, (5) support of R&D in industry, (6) support of R&D in universities, (7) support of higher education in engineering and science. Give Primary function (if applicable).

Scientific discipline: (1) engineering and technology, (2) natural sciences: (a) agricultural sciences, (b) astronomy, (c) atmospheric sciences, (d) biological

sciences, (e) chemistry, (f) mathematics, (g) medical sciences, (h) oceanography, (i) physics, (j) solid earth sciences, (3) social sciences: (a) anthopology, (b) demography, (c) economics, (d) political science, (e) psychology, (f) sociology. Give primary, secondary and tertiary discipline (if applicable).

Areas of application: (1) nuclear energy, (2) space travel and communications, (3) war and defence, (4) agriculture (inc. fisheries and forestry), (5) construction, (6) transportation, (7) telecommunications, (8) health, (9) industry, (10) underdeveloped areas, (11) economic and fiscal policy (national and international), (12) regional development, (13) social welfare and social policy, (14) educational techniques and policies, (15) administration, (16) other (please identify). Give primary and secondary areas if applicable.

Above to be tabulated for each of the fiscal years 1962-1963 to 1966-1967, estimates for 1968-1969, and projections for the five fiscal years beginning 1969-1970.

b) Operating and capital funds expended by the units described in (2.1 c.) (e.g. divisions, sections, etc.) for the fiscal years 1962-1963 to 1966-1967 inclusive, estimates for 1967-1968, and five year forecasts for fiscal years 1969-1970 to 1973-1974.

c) Funds expended to further professional university education of staff for each of the fiscal years from '62-'63 to '68-'69 inclusive (e.g. costs of educational leave to take higher degree, payments to cover costs of taking courses at local universities).

2.7) *Research Policies*

In the following, the term "project" is used very broadly to describe a distinguishable discrete research activity; this could range from scientific research orientated to extend the range of understanding of one item within a particular discipline to an interdisciplinary research and development task. The term "programme" is used to denote a planned goal-directed scientific activity requiring more than one "project" for its accomplishment. In other words, it is through a series of related "projects" that a "programme" is conducted.

a) *Units concerned with intramural research activities*

1) Describe process whereby various types of programmes and projects are selected, initiated and monitored (e.g. what role do other Federal agencies or units play in this process).

2) How are priorities established between programmes and projects and in what terms are priorities expressed and implemented.

3) Are network methods such as Critical Path Network or Programme Evaluation and Review Technique (CPN or PERT) used to plan and monitor programmes and projects; briefly list current examples of such use.

4) What uses have been made during the last five years (and are being made currently) of contracting out projects in support of intramural programmes. In what sectors have these contracts been let (cite cases-in-point).

5) What are the policies regarding the funding of extramural research programmes in the universities and industry. How are they related to the policies governing intramural programmes and to other Federal agencies.

6) In a changing technical environment it becomes necessary at times to shift research resources from one programme (possibly even terminating it) to a new programme. By what process is this done and describe any current difficulties.

7) How are intramural and contracted extramural research results *transferred* to those having potential need of them (e.g. industry, other government agencies or universities).

b) *Units exclusively concerned with extramural research activities*

Some units' sole activity in the field of the Committee's concern is the funding of extramural scientific activities.

1) Describe process whereby various types of programmes and projects are accepted for funding and describe what relation these factors have on the acceptance process:

i) Previous record of achievement of unit or individual requesting funds
ii) Nature of proposed project
iii) Policies of granting agency

2) How are priorities established between programmes or projects.

3) How are projects monitored and the results evaluated.

4) How are priorities implemented in the allocation of resources to programmes or projects.

5) Are network methods such as CPN or PERT used to plan and monitor programmes or projects; briefly list current examples of such use.

6) In a changing technical environment it becomes necessary at times to shift research resources from one programme (possibly even terminating it) to a new programme. By what process is this done and describe any current difficulties.

7) How are extramural research results *transferred* to those having potential need of them.

8) What percentage of funds *available to* the agency for the support of extramural scientific activities were actually expended during each of the fiscal years '62-'63 to '66-'67.

9) What percentage of the total funds *requested* from the agency were in fact *granted* in each of the fiscal years '62-'63 to '66-'67.

2.8) *Research Output*

The previous items have been concerned with "inputs" to research activities and the state and manner of organization of the research process. The following items refer to the research "output" and it is understood that such measures have limitations. Please give brief details regarding the following for each of the years 1962 to 1967 inclusive:

1) Patents arising from research activities. Number of licences granted and value of resulting production in Canada and elsewhere.

2) Books or journal articles arising from research activities.

3) Reports issued from agency and units.

4) Conferences or other means used to transfer information regarding the results of a project or programme to extramural groups.

5) That means for the transfer of scientific and technological data obtained from countries outside Canada, to extramural groups.

6) Individuals who had the opportunity to train themselves in specialized fields whilst employed with you and subsequently left and made important contributions to their field.

7) Research teams that have arisen in this period and who have unique and valued abilities in important fields.

8) Unique or valuable research tools, facilities, or processes added or developed during the above period.

9) Details concerning the impact of your scientific activities and research output on the advancement of scientific knowledge and Canadian economic development.

10) Any other measures or indications of research output.

2.9) *Projects*

1) For each unit responsible for scientific activities, (intramural or extramural), list the titles or other brief descriptions of projects which were conducted during each of the years from 1962 to 1967 inclusive. Indicate projects that are part of an overall programme and briefly describe the programme.

2) Present case histories of what you consider as the most significant completed projects of the last five years. These should be selected as exemplars of what are considered to be the results of the agency when operating in its role with maximum effectiveness; in other words, examples of what the agency considers among its "best work". The projects selected, when possible, should be presented under the broad categories of "basic research", "applied research", and "development", and it is suggested that no more than *five* are to be singled out in any one category.

2.10) *Organizations not currently engaged in scientific activities*

The Special Committee on Science Policy was constituted to consider and report upon those agencies of the Federal Government directly engaged in scientific activities. The Committee was also charged with recommending a science policy for Canada and is of the opinion that any government policy related to science must take some account of the effects of science on all governmental functions including those of agencies or

units not engaged in scientific activities. The Committee, therefore, invites all agencies under the jurisdiction of the Federal Government to include in their briefs comments as to the effects of scientific activities on their own operations and in particular, to comment on the following items:

1) Forecasts of the effects of changes in *technology* on the agency's operations, functions and responsibilities during the next 5 to 10 years.

2) Studies of possible improvements in the agency's effectiveness due to new scientific or technical developments.

3) The type of scientific or technical advice sought during the last five years; the source of this advice.

4) Future plans determined by, or designated to take account of, recent scientific and technical developments.

APPENDIX A

SENATE OF CANADA

Special Committee on Science Policy
27th Parliament

ORDER OF REFERENCE

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

a) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

b) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

c) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

d) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel and technical and clerical personnel as may be necessary for the purpose of the inquiry; and

That the Committee have power to send for persons, papers and records, to sit during sittings and adjournments of the Senate, and to report from time to time.

That the said Committee be authorized to print such papers and evidence from day to day as may be ordered by the Committee.

That the Committee be composed of the Honourable Senators Aird, Argue, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Hayes, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, McCutcheon, Phillips, Sullivan, Thompson, and Yuzyk.

APPENDIX B

Some definitions

1. *Scientific activities* comprise all activities concerned with the creation or acquisition of new knowledge in engineering or the natural and social sciences, or with new applications of scientific knowledge to useful purposes. Five classes of activities are to be distinguished: research and development (R & D), data collection, scientific information, testing and standardization, and education in the sciences and engineering.

1.1 *Research and Development* [*R & D*]

a) *Research* is investigative, experimental and generally original work undertaken for the advancement of scientific knowledge (i.e. scientific information when arranged in logical systems or theories). Research is *basic* when it has no immediate specific practical application (although it may be oriented towards an area of interest to the performer); it is *applied* when it is directed towards a specific practical application.

b) *Development* is the use of knowledge derived from research in order to produce new materials, devices, products and processes, or to improve existing ones.

1.2 *Data Collection* refers to the routine and continuous collection and arrangement of

data on natural and social phenomena. It includes geological, topographical, hydrological and oceanographic surveys and mapping, collection of meteorological data, collection of social and economic data, and the gathering and arrangement of human, biological, entomological and zoological specimens and data.

1.3 *Scientific Information* refers to the dissemination of scientific and technological information, including any necessary preliminary work such as recording, classigying, translating or coding. Expenditures attributable to this activity include the costs of libraries of scientific and technical publications, the costs of national patent offices and government scientific and technical information services, the costs of scientific conferences or displays, and the costs of publishing information acquired as a result of some other scientific activity.

1.4 *Testing and standardization* refer to work directed towards the establishment of national standards for materials, devices, products and processes, the calibration of secondary standards and non-routine quality testing, separately identifiable from R & D, which may be required to identify the characteristics of materials, devices, products and processes.

1.5 *Education* refers to education and training in engineering and technology or the natural and social sciences at institutions of higher education. The Federal Government's direct participation in this activity is mainly through scholarships and fellowships intended to assist students with their educational expenses.

2. *Intramural*—done within the reporting organization, i.e. agency or unit.

3. *Capital expenditures*—expenditures on land, buildings and non-expendable research equipment used for R&D and other scientific activities. In the case of multipurpose facilities, capital expenditures should be apportioned between scientific and non-scientific activities (or between R&D and other scientific activities) on the basis of proportion of time devoted to various activities.

4. *Personnel classifications:*

4.1 *Professionals:* personnel with at least one degree from a university or college plus those without such formal qualifications who are in job classifications for which such qualifications are normally required, (i.e. research scientist, statistician, economist).

4.2 *Technicians:* technically trained personnel who assist professionals engaged in scientific activities. Normal qualifications are certification by provincial education authorities or by scientific and engineering associations (provincial and national). Also included are personnel who do not have such certification but who are in job classifications for which such qualifications are normally required (e.g. technical officer).

4.3 *Workers:* skilled craftsmen or unskilled help who assist professionals and technicians in their work (e.g. machinists and electricians).

4.4 *Other supporting personnel:* administrative personnel such as clerks, typists, accountants and storemen. (Do not include persons only indirectly involved in scientific activities, such as janitors, cafeteria workers and security guards, or persons engaged in the construction of facilities for scientific activities.

5. *Agency and unit*

a) *Agency* is the term used for organizations under the jurisdiction of the Federal Government such as Departments, Crown Corporations, Commissions or Boards.

b) *Units* denote groups (e.g. sections or divisions) operating within an Agency.

APPENDIX 2

BRIEF

BY THE

NATIONAL RESEARCH COUNCIL OF CANADA

NATIONAL RESEARCH COUNCIL OF CANADA

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NATIONAL RESEARCH COUNCIL OF CANADA

(A REPORT IN SUPPORT OF THE BRIEF
PRESENTED TO
THE SENATE SPECIAL COMMITTEE ON SCIENCE POLICY)

I. STATUTORY RESPONSIBILITIES AND FUNCTIONS

Under the National Research Council Act (Appendix A), the Council has been assigned a broad responsibility "to undertake, assist or promote scientific and industrial research", and "has charge of all matters affecting scientific and industrial research in Canada that may be assigned to it by the [Privy Council Committee on Scientific and Industrial Research]". In general terms the role of the Council is that of developing and nurturing a national capability in scientific and industrial research, and of deploying scientific research for national benefit.

In order to carry out these broad functions, and to ensure that the Council is responsive and adaptive to changing needs and new opportunities, a continuous and detailed monitoring of the whole of science and engineering is essential. The broadly representative character of the Council itself, as well as a strong cadre of advisory and associate committees, provide the Council with the board and detailed input necessary for decision-making and policy formulation on all aspects of scientific research in Canada. In this respect the Council also derives a special advantage from its own laboratories, whose staff represent a broad spectrum of scientific expertise and maintain close contact with industrial laboratories,

university laboratories, and other federal government laboratories.

The development and support of a strong indigenous science requires provision for research manpower training, support of research operations and experimental research facilities, common research services (as for example, library and scientific information services, scientific publications, standardization, analytical services, etc.), research co-ordination, scientific societies, research conferences and other activities which, in aggregate, contribute toward a favourable research environment.

The research activities sponsored by the National Research Council are intramural and extramural. In recent years there has been greater emphasis toward extramural research support, due in part to a rapid expansion of university research activities and in part to an urgent need to promote and assist industrial research.

II. ORGANIZATION

The National Research Council of Canada consists of the President, the Vice-President (Administration), two Vice-Presidents (Scientific) and not more than 17 other members appointed by the Governor in Council. The Council is a body corporate and is required to meet at least three times a year in the city of Ottawa.

The Council is responsible to a designated minister who is a member of the Committee of the Privy Council on Scientific and Industrial Research. Mr. C.M. Drury, President of the Treasury

Board is the present Minister reporting to Parliament for the National Research Council. Except for the four permanent officers, Council members are appointed for a term of three years and serve without salary. Council members are drawn from the senior staff of Universities, Industry and Labour, with an attempt to achieve a broad base of advice, both as to scientific discipline and regional representation.

A recent executive re-organization has provided, in addition to the statutory Vice-Presidents, two additional senior positions and a more functional re-arrangement of responsibilities. Areas of responsibility are detailed in the organization chart (Appendix B).

The N.R.C. laboratories are now organized in ten divisions and two regional institutions - the Divisions of Biosciences, Applied Chemistry, Pure Chemistry, Applied Physics, Pure Physics, Building Research, Mechanical Engineering, the National Aeronautical Establishment, Radio and Electrical Engineering and the Division of Radiation Biology, plus the Atlantic Regional Laboratory and the Prairie Regional Laboratory. The necessary administrative services are organized separately to take as much of the administrative burden as possible off the shoulders of the people who are actually doing the research. In addition, there is a vast network of committees which are involved with advising Council as well as being active in the conduct of Council business. This very important structure is portrayed in Appendix C. This committee structure draws heavily for

its membership on the whole scientific community of Canada and provides a very extensive role in information dissemination, as well as contributing to the co-ordination of scientific activities across the country.

III RESEARCH ACTIVITIES AND OPERATIONAL POLICIES

III-1 UNIVERSITY GRANTS AND SCHOLARSHIPS

The basic objectives in supporting academic research are the training of research manpower and the acquisition of new scientific knowledge. From its inception, the program of scholarships and grants-in-aid of research developed by the National Research Council, has been based on a number of fundamental principles:

1. Academic freedom and university autonomy must not be infringed upon. The individual professor has complete freedom to plan his own research with the consent of university authorities.

2. Research grants awarded by the National Research Council are considered grants-in-aid and are not intended to cover the complete costs. For this reason Council has been reluctant to pay "overhead" costs, but a general research grant is currently given to the university president to provide a flexible contingency fund.

3. Under our Constitution, provincial governments have the primary responsibility for education. Scholarships and research

grants are therefore confined to graduate students and the researches of staff members.

4. Council has traditionally placed more emphasis on supporting the gifted individual than on supporting the project, department or institution. Experience has shown that unless there is demonstrated competence in the individual, the funds expended rarely produce significant research results.

5. While Council has generally sought to support excellence, special consideration has been given to supporting promising individuals and groups in the emerging universities and developing disciplines. This has been done through "starting grants" to young applicants who are new staff members, through supplementing the general research grants to institutions, and by negotiated development grants.

At present the awards policy is determined by three Standing Committees of Council, namely: (1) Committee on Scholarships and Fellowships; (2) Committee on Annual Grants, and (3) Committee on Negotiated Grants. About one hundred academic representatives from a wide spectrum of universities and disciplines are appointed, on a rotational basis, to serve on the grant selection committees that review and assess all grant requests. In addition, they make recommendations on major equipment requests and support of research institutes. Negotiated development grants are intended to provide an initial stimulus (normally three years) for

important scientific and mission-oriented research activities in localities and in disciplines where such a stimulus is considered necessary. Past experience has shown that a number of different programs are needed to meet various objectives and new requirements as they arise. Periodically new programs are initiated on an experimental basis and those that are unsuccessful or become outdated are discarded. More complete details are given in the publication "Support of Research in Canadian Universities by the National Research Council of Canada, March 1968".

An important criterion in assessing excellence in the scientist is the number and quality of his scientific papers, patents, products and processes. Scientific achievement can be evaluated on the basis of articles published in competently refereed journals and such papers are available for further scrutiny by grant selection committees.

The policy of the National Research Council is to support competent research in all fields and disciplines of natural science. Some projects may fall in interdisciplinary fields at the interface of the natural and social sciences. It has been the policy of Council to take a flexible position in these borderline areas. Individual scientists and universities also receive research support from other government departments and agencies. A number of formal and informal liaison committees have been set up with representatives of these agencies.

Within the grants program the main shift in resources has been towards support of new growing points in science which, with a fixed budget, naturally reduces the amount available in more well-established fields. At the present time all funds available to Council for university support are allocated and these seldom meet more than 60% of the requests received. Appendix D summarizes funds awarded during the past five years.

During the past fifty years, the National Research Council of Canada awarded some 11,000 scholarships to over 5,000 individuals. The growth rate of the program for the past five years is shown in Appendix D. The Council awarded over 2,500 scholarships in the current year. A survey (Appendix E) shows that about 45% of NRC scholars are currently employed in universities while 25% are in industry, and 25% in Government laboratories. Most of the scholars found employment in Canada, though at any given point in time some 20% are employed in the U.S. However, one third of these will eventually return to Canada.

III-2 THE INDUSTRIAL RESEARCH ASSISTANCE PROGRAM

This Program (IRAP) was initiated in 1962 as the third of five government programs to stimulate applied research in Canadian industry. It is specifically directed to establish a number of competent research teams in manufacturing companies in non-defence areas, with industry bearing at least half the cost. It is

generally comparable with the Defence Industrial Research Program (DIR) in National Defence and is complemented by the Program for the Advancement of Industrial Technology (PAIT) in the Department of Industry.

Administration is handled by N. R. C., which has appointed Committees representing industry, university and government interests to establish guidelines and ground rules, and to approve grants. Particular emphasis has been laid on reducing administrative requirements, conditions of grant and supervision of projects to the bare essentials, and on flexibility in meeting industrial needs as the Program develops.

Proposals of a company's own choice may be submitted, at any time, in a prescribed format. They are examined by the N. R. C. Secretariat as to general eligibility, and assessed by senior scientists from N. R. C. and appropriate government departments as to the quality of the research and the personnel to be employed. They are then reviewed by a Committee of senior executives from government departments and agencies concerned with industrial research and production, commerce and finance, who also provide cross representation on DIR and PAIT Committees.

The Committee ensures that funds are not concentrated unduly in any one company, industrial field or geographical area, and that the research is related to improvement in the national economy. Scientific liaison officers are appointed to each project

to observe progress and make government resources available as necessary. Projects are treated as commercially confidential and companies retain all patent rights. Grants are non-recoverable and apply to relatively long term applied research of three to five years duration. They are renewable each year, subject to satisfactory progress, and companies may re-orient or enlarge their programs. Support is limited to the salaries of research personnel added to the company staff on a permanent basis, salaries of university professors serving as advisors, and university summer students. Although each project must have a process or a product field in view, commercially applicable results are not necessarily expected within the term of support. Subsequent R&D required to convert laboratory results into commercial products is not supported, this being a function of PAIT.

Growth has been at a natural rate governed by initial shortages of senior scientists, time to build laboratories, and the share of company funds available for investment in the IRAP. Detailed records kept of each project reveal a definite increase in laboratory facilities and the number and quality of research personnel attributable to IRAP. Over half of the 131 companies involved are new to research and only 17% also receive support from PAIT and DIR. About 25% of the companies are small and several have been successful, although the failure rate is higher in this sector. Many large companies have expanded their facilities and research budgets

considerably, undertaken more sophisticated research and entered new fields, including some areas previously left to government. Most response has come from Ontario and Quebec, a good response from Western Canada and very little from the Atlantic Provinces. The projects have served as focal points, bringing government, university and industrial scientists together and improving communication, leading to increased use of government and university resources and a better understanding of industrial needs.

Research costs per professional compare quite favourably with those current in U.S.A. and Canadian industry. The cost sharing ratio has changed somewhat, the average company share increasing from 51% to 57%. Although funds have been sufficient to support all suitable projects until the current year, the entire Program only compares in personnel and budget with that of a medium-sized industrial laboratory in the U.S.A.

IRAP activities and results are documented in more detail in Appendix F.

III-3 INTRAMURAL RESEARCH - NRC LABORATORY PROGRAMS

Rather than attempting to enumerate the work of each Laboratory Division in any detail, this brief survey will emphasize the philosophy and policies behind their operations with some illustrative examples here and there. A condensed listing of Research Projects is given in Appendix G. A fuller account of the various

Divisional programs are published annually in the "Review of the National Research Council of Canada". (Published by NRC, Ottawa, Canada, N.R.C. No. 10159).

The internal scientific programs have been grouped under twelve Divisions, ten in the Ottawa area, one at Halifax and one at Saskatoon. With two or three exceptions, the titles of the Divisions (as of March 1968) are descriptive of their current research programs in broad terms only, since some of the designations have not kept pace with the continuous metamorphosis of the respective divisional programs. However, the organization is flexible and re-alignments, both intradivisional and interdivisional, are continually underway, not for administrative convenience, but to adapt the available resources to changing conditions and demands through selection and concentration. The NRC's internal policy is designed to emphasize the interdisciplinary approach to to-day's research problems which often require a multi-faceted attack.

The broad goals of the NRC are both a deeper penetration into the secrets of nature and the application of the knowledge so gained to human problems, with a view to improving our society both intellectually and materially. At the present time, the major part of our research effort as measured in terms of both men and dollars, is devoted to programs that appear to promise more immediate material returns, but this does not necessarily imply that more

importance is attached to short term applied work. In part, this also reflects the price of providing to the country certain special R&D facilities too expensive for industry to afford, such as wind tunnels, seaway models, ship basins, antenna ranges and fire research facilities. For the most part, research programs tend to be of the longer-range exploratory type. Although devices and products frequently result, the primary objectives should be feasibility and 'know-how', rather than product development. The latter is more appropriately carried out in industrial laboratories, or by co-operation with industries.

The Divisions of Pure Physics and Pure Chemistry engage in selected basic research, where the main guiding principle is to support highly competent investigators who, themselves decide to a great extent the direction the work will take. A wise administration does not attempt to direct closely or to channel basic research while it is in progress. Its role is to assess the results, from time to time, in order to decide whether to continue and enlarge the support or to withdraw from the field. The judgment of scientists world-wide is the most useful factor in determining the value of basic research, whether or not that knowledge shows promise of application. In addition, the administration may indeed try to evaluate the practical potential but this is very difficult. Sometime, somewhere, it is a virtual certainty that any front-line research will be utilized in some

form for man's material betterment.

At the other end of the research spectrum are the Division of Building Research and the National Aeronautical Establishment which could be described as "mission-oriented". DBR's programs are tailored to its role as a research and information agency serving both the construction industry across Canada and other government departments and agencies, notably Central Mortgage and Housing Corporation. The major efforts of NAE's laboratories are directed toward problems of the aerospace industry. NAE also acts as the aeronautical research arm of DND and DOT. In both Divisions the majority of the programs and projects are closely monitored and co-ordinated at all levels, since the desired end products, whether hardware or information, are as a rule determinable in advance. Both of these Divisions do undertake some fundamental researches, from time to time, where the initiative usually stems from the needs of the applied programs.

The Division of Mechanical Engineering is also near the applied end of the spectrum. Broadly speaking, the major activity of DME is in the transportation field - land, sea and air. In particular, the St. Lawrence Seaway has received considerable attention for several years, and investigations into other aspects of coastal engineering and river hydraulics are also current. The railways have come to rely on the Division for advice on their

problems. In the aeronautical field, of course, the Division works intimately with NAE to ensure that their respective programs dovetail.

Somewhere midway along the spectrum may be found the Divisions of Applied Chemistry, Applied Physics, Biosciences and Radiation Biology. The programs of these Divisions are oriented towards solutions of practical problems, but they also endeavour to allocate some of their resources to fundamental work for which a "pay-off" in material terms may be many years ahead. Acoustics and photogrammetry are but two examples of major programs in Applied Physics which are geared specifically to obtaining practical answers of use to industry and government, and for which there have been created special facilities unique in Canada. Many of the physical standards that have been established to date were developed in the Division of Applied Physics - a process that continues to demand basic research of the highest calibre. Radiation Biology was recently set up to investigate the effects of radiation on living creatures. However, since this is closely related to several . biological investigations now under way in the Division of Biosciences, a coalescence of the programs of these two Divisions is now under way. The emphasis of these programs is on research into the physical and chemical aspects of biology as contrasted to the medical and clinical aspects. The Division of Applied Chemistry has been involved in the development of several important commercial

processes. However - and this is typical of the NRC as a whole - the Division's reputation as advisor and consultant to the chemical industry is sustained by good men in basic research who are strongly motivated to "following through" in applied work.

The largest unit, the Radio and Electrical Engineering Division, is perhaps also the most heterogeneous, since its activities range from radio astronomy and the physics of surfaces on one hand to the development of radar antennas and navigational aids on the other. Provided the sub-units are not too small to be viable this heterogenity (which also exists to a considerable degree in the other Divisions) has been shown to be most effective in cross-pollinating the ideas of the basic and the applied scientists.

The Prairie Regional Laboratory, located on the campus of the University of Saskatchewan, and the Atlantic Regional Laboratory on the grounds of Dalhousie University, were established to carry out investigations peculiar to the local conditions and in this endeavour they have been moderately successful. In both cases the scope of their programs has been biological in nature, broadly speaking, with the emphasis at PRL leaning toward agricultural developments and at ARL toward utilization of products of the sea.

III-4 ASSOCIATE COMMITTEES

The National Research Council Associate Committees have proved to be one of the most effective instruments for studying, co-ordinating and promoting research on problems of national significance. The members of these committees are experts in the different aspects and disciplines related to the problem and are drawn from university, industry and government laboratories. Such representation brings to the committee a multidisciplinary capability and a diversity of research resources. An associate committee collects and collates the necessary information, delineates research problems, co-ordinates research and, if necessary, may initiate new research. Over the years these committees have been very successful and this mechanism has been adopted in other countries.

A few committees have been in existence for over 40 years and continue to record notable accomplishments but others have performed their task and been disbanded. Currently there are 42 associate committees dealing with a wide variety of national problems (see Appendix C). To exemplify the inter-disciplinary nature of their research activities, the diversity of problems and methods of operation, the work of four selected committees is outlined below.

Grain Research

The Associate Committee on Grain Research is one of the Council's oldest associate committees. The excellent baking quality of Canadian wheat was established by the variety Marquis, but it was susceptible to rust. For over 40 years new rust-resistant varieties have been produced continuously by the Canada Department of Agriculture, but their baking quality has to be determined to confirm that they are "equal in quality to Marquis" as required by the Canada Grain Act. The committee devised procedures for testing the baking quality of exceedingly small samples followed by the application of these tests to the new varieties. Prior to the establishment of the National Research Council's laboratories, this work was done in university laboratories under grants made by the committee.

Procedures for testing the quality of other cereals and oilseeds (macaroni wheat, malting barley, rape seed, etc.) have also been developed by the committee. Application of all these tests is now routine and is done largely by government and industrial laboratories but the committee interprets the results in terms of quality and makes its recommendations to competent authority. Other studies by the committee have provided the basis for modern grain-drying and grain-grading procedures including an examination of their suitability for new baking

technologies. These committee activities have improved quality and established a high level of confidence in Canadian grains that has increased exports. This objective could not have been attained without close co-operation between specialists in university, government and industry.

National Building Code

All building must conform to certain minimum standards in the interests of public safety. Under our Constitution building regulations are a provincial responsibility and these have been delegated by provincial governments to municipal authorities. This has led to a diversity of local building bylaws that were often conflicting. As early as 1941 Council, as a result of the first Dominion Housing Act, produced a model bylaw or code that could be used by municipalities.

In 1948 responsibility for the Code was assumed by the Associate Committee on the National Building Code, supported by technical and secretarial services provided by the Division of Building Research. The committee is made up of experts from all parts of the country, from all segments of the construction industry, plus public interest representatives. Revised and improved versions of the Code were issued in 1953, 1960 and 1965, and further revisions will appear at five-year intervals. Adoption of this Code remains a voluntary matter but it is now used as a

guide for all federal construction, is mentioned by name in the Municipal Acts of six provinces, and is used by the four other provinces and 80% of the cities in Canada. In effect it has become the building regulation for over three-quarters of the Canadian population.

Geodesy and Geophysics

The physics of the earth or "geophysics" encompasses studies far beyond that of a single discipline and its practitioners represent a multitude of scientific disciplines. No other nation compares with Canada in the range of opportunities for geophysical research. For example, the North Magnetic Pole, the Polar Continental Shelf, and the Canadian Shield all lie within its territory. One-third of the fresh-water in the world is in Canada, we border on three oceans, the Great Lakes, and have vast areas of snow, ice, glaciers and permafrost.

This rich field for scientific study presents problems as well as opportunities. An adequate network of survey and monitoring stations covering our vast territory is required to provide data for meteorology, seismology, gravity, magnetic and other surveys. The Associate Committee on Geodesy and Geophysics provides a national forum for scientists from universities, federal and provincial governments and industry. It also acts as the Canadian member of various International bodies devoted to

International co-operation and scientific exchange in this field.

Agricultural and Forestry Aviation

While the combination of aviation expertise and the products of modern chemistry have been of inestimable benefit to world food production, the social and financial benefits of aerial spraying of pesticides are sometimes accompanied by side-effects that present formidable problems. Aerial application of agricultural chemicals in Canada is increasing at a rate of nearly 20% annually. Ideally, these biologically active chemicals should be applied in just the necessary and sufficient concentration. If this ideal is not achieved, the process is inefficient and may contribute to pollution of our soil, air and water in addition to undesirable acute effects.

The Associate Committee on Agricultural and Forestry Aviation was set up in 1965 to provide a medium for communication between specialists in the agricultural, foresty, medical and aeronautical sciences, regulatory agencies of government, commercial suppliers of agricultural chemicals and aerial spray operators. During its three years of existence, the Committee has made working contact with actively interested organizations and individuals in all the provinces of Canada, with appropriate organizations in the United States and overseas, and with the International Agricultural Aviation Centre at The Hague.

III-5 SCIENTIFIC AND TECHNICAL INFORMATION SYSTEMS

a) TECHNICAL INFORMATION SERVICE

This Service helps small secondary manufacturing companies to keep abreast of new developments in technology and research on a no-fee basis. Field engineers, all university graduates with many years of industrial experience, operate from eleven field offices across Canada and personally visit companies to discuss their problems.

The Service operates in three sections. The Technical Enquiry Section provides information to solve production problems concerning the properties and processing of materials. If a field officer cannot answer the query directly, it is referred to the T.I.S. staff in Ottawa, also engineers with widely varying industrial experience. They have numerous sources of information located in government laboratories and departments, in the National Science Library and its vast network of library resources, in large companies and industrial associations, and in foreign countries. The answer gives background information on the problem, articles and texts applicable to its solution, advice on how to use the information, a bibliography of other material to enable the enquirer to study the problem further, and the location of this material.

The Industrial Engineering Section assists companies

on a do-it-yourself basis to resolve their operating problems. This is done by supplying information, guidance and assistance in the analysis of work situations, improvements to production processes and facilities and implementation of systems by which management can operate and control production processes for optimum results.

Companies are encouraged to train their staff in industrial engineering techniques and are advised on sources of training or consulting services of a specific nature.

The Technological Developments Section provides information selected as having particular application to Canadian industry. It provides Technical Reviews of new developments, giving a summary of the state of the art and a bibliography of up-to-date references. It has sponsored a small collection of technical films covering industrial engineering techniques and new production processes, administered for it by the National Film Library.

Its major effort is concentrated on providing Check-lists of titles of articles, selected from hundreds of technical journals and other sources as being suitable for particular fields of industry and for particular companies in each field. Computer techniques are used to match the special interests of some 3,000 participating companies with this selected material. The items

requested by the companies from these Checklists are then used to provide further Checklists for the remaining 27,000 odd companies not registered in the computer program.

T.I.S. also exchanges considerable information with similar organizations in other countries and has assisted some developing countries by training personnel and answering their industrial queries.

The Enquiry Service has been operating for twenty-three years and has built up a clientele of both large and small companies. Their continued use of the service indicates its value and some 14,000 queries are answered annually. The Industrial Engineering Service is filling a major need, the material benefits of which are quite obvious in improved productivity. The Technological Developments Section is still experimental in nature but a definite need has been indicated by industry, which has been most co-operative in developing the service. This probably will become the largest section in T.I.S. The co-operation with foreign countries presents an opportunity for an organized and inexpensive program of external aid to fill a technical need not covered by existing programs. Its operations are described in more detail in Appendix H.

b) NATIONAL SCIENCE LIBRARY

The National Science Library, the major science library in Canada, is a responsibility of the National Research Council under its Act. It is essentially an information transferral agency. Its activities are designed to provide Canadian scientists, engineers and industrialists with direct and immediate access to publications and information required in their day to day work.

The Library's resources of 725,000 volumes have been developed in close co-operation with other federal libraries, to the point where there exists one of the world's outstanding collections of scientific and technical literature. The NSL's services reinforce and supplement local information services rather than supplant or replace them. Through these co-operative measures and utilization of Telex linkage with world-wide information services, the NSL serves as the focal point of a national scientific and technical information network.

Typical of large science libraries, periodicals or journals account for 80% of the NSL's collection. Of the 16,000 journals currently received approximately 2000 titles are obtained through exchange agreements with 61 countries. The Library is a depository for publications issued by such agencies as the U.S. Atomic Energy Commission, U.K. Atomic Energy Authority, Rand Corporation, NASA and the U.S. Clearinghouse for Federal

Scientific and Technical Information. Publications from this latter agency are received in the form of microfiche representing 20,000 technical reports per year.

In November 1966 the NSL was assigned the additional responsibility of serving as the national bibliographical centre for the medical and health sciences. In keeping with this assignment the Library is strengthening its medical collection and now receives all but 150 of the 2,300 journals indexed regularly by Index Medicus.

The Library's resources are publicized by a wide variety of publications which are compiled using computerized techniques and distributed at regular intervals, and without charge, to libraries and scientific organizations across Canada. Its information services are carried out by a staff having science or engineering degrees or experience, and who are skilled in the art of answering requests for scientific information, in carrying out literature searches, compiling bibliographies and providing an SDI (Selective Dissemination of Information) service using both conventional and mechanized techniques.

The Library's mechanized SDI service utilizes a computer to scan the contents of 3000 journals and provides 130 scientists in the Ottawa area with weekly lists of papers in their specific fields of interest. Steps are now being taken to extend

this service on a national scale.

The provision of loans or photocopies of scientific papers is an integral part of the NSL's information services. At present an average of 300 such requests are processed daily - 50% from industrial firms, 30% from universities and 20% from other organizations and individuals.

The NSL's Translations Section maintains the "Canadian Index of Scientific Translations" which records the availability of more than 200,000 translations of foreign language papers. This Section also distributes to interested scientists copies of the 1300 translated papers prepared for NRC scientists, and publishes a cover-to-cover translation of the Russian journal Problemy Severa (Problems of the North).

During the ten year period 1957-1967, the Library's collection expanded from 350,000 to 725,000 volumes. The number of loans and photocopies provided grew from 59,000 to 155,000 per year, while the requests for factual information, literature searches and bibliographies increased from 3400 to 24,000 per year.

The N.S.L. has grown to a point where it completely fills its available space designed 38 years ago. A new building to house the material and the personnel who work with it is at the architectural design stage and hence several years away at best. Until new premises are available, library services will be

adversely affected by the congested situation.

c) SCIENTIFIC PUBLICATIONS

The culminating step for most scientific researchers is the publishing of a research paper and thus the publishing of research papers is an integral and important part of the research process. As a major contribution to disseminating the results of research activities, the National Research Council entered the scientific publishing field in 1929 with the Canadian Journal of Research, a monthly publication. Keeping pace with the expansion of research in Canada, the initial Journal has proliferated through various intermediate stages so that now the Council publishes eight Journals covering the fields of Biochemistry, Botany, Chemistry, Earth Sciences, Microbiology, Physics, Physiology and Pharmacology, and Zoology. Two of the Journals are published bi-monthly; four are published monthly and two semi-monthly.

The continuing increase of research in Canada maintains a pressure on the Journals to grow in step. Thus the Journals as a whole tend to double in size every $6\frac{1}{2}$ years, or about an average of 15% per year. This growth, of course, is not evenly distributed by years or Journals. For instance, in 1967 the Journals as a whole published 1,911 papers in 17,168 pages--an increase of about 21% over 1966. The source of papers continues fairly steadily at

70% Canadian papers to 30% papers from other countries.

d) INTERNATIONAL EXCHANGES

The Office of International Relations has responsibility for the participation of the National Research Council in formal international scientific activities. The National Research Council is the adhering body in Canada for the International Council of Scientific Unions and most of its constituent unions. The National Research Council also holds membership, on behalf of Canada, in many other international scientific associations and organizations. In addition, the National Research Council, in conjunction with the Department of External Affairs, has responsibility for Canadian participation in the activities of the Nato Science Committee and some of the scientific committees of the Organization for Economic Cooperation and Development.

The National Research Council operates a scientific liaison office in London with responsibility to maintain relations with scientific organizations in the United Kingdom and to report on scientific and technical developments.

The National Research Council has a scientific exchange agreement with the Soviet Academy of Sciences which provides for visits of scientists ranging from three weeks to nine months. The Council has also accepted certain obligations for the exchange of scientists with France within the terms of the Cultural Agreement

between the Government of the French Republic and the Government of Canada. Copies of these agreements and related information is detailed in Appendix I.

Of the 16,000 journals currently received by the National Science Library and using the Canadian Journals of Research as exchange media, approximately 2,000 are received from other countries on an exchange basis. Exchange agreements have been established with 61 countries, the majority of which are located in Europe.

III-6 RESEARCH SERVICES

a) STANDARDS AND CALIBRATION

In any country it is essential to both science and commerce to have access one way or another to a wide range of international physical standards. Accordingly the NRC is slowly building up a range of physical standards and has established to date a number in the fields of acoustics, colourimetry, electricity, mechanics (force length, mass, hardness etc.), optics, temperature time and frequency, and nuclear radiations. Some of the contributions in this field have been outstanding for example, the Canadian neutron standard has been accepted as the world standard.

Calibration services typically involve either a direct comparison between the user's instrument and the primary standard or a sequential comparison which interposes a secondary

working standard. Since the NRC can scarcely be called upon to calibrate everyone's thermometers or scales, practical arrangements are usually worked out whereby the NRC will from time to time certify the accuracy of secondary standards, which may be maintained by a government department with regulatory powers, such as Trade and Commerce, or even by a commercial firm. As an example of the latter practice the Department of National Defence contracts with one or more commercial firms to supply DND with calibration services, with the provision that the secondary standards employed by the firm are to be periodically certified by NRC.

b) RESEARCH TOOLS AND SPECIAL FACILITIES

Over the years the NRC has built up a large inventory of research tools and facilities, many of which are unique in Canada. Some of these are designed to support basic research programs, such as the Algonquin Radio Observatory, and the Churchill Research Range, while others, including the family of wind tunnels, the antenna ranges, and the ship testing basins, have been built in response to the needs of the industrial community.

The world's best radiotelescope for the reception of microwave radiation is at the Algonquin Radio Observatory and much of its observing time is booked by astronomers from

Canadian universities, the Department of Energy, Mines and Resources, and some foreign observatories. The Churchill Research Range, at Churchill, Man., is a large complex for the support of the launching of scientific sounding rockets for studies of the upper atmosphere. The U.S.A. built the range originally and currently contributes half the operating cost. At present, U.S. scientists launch about twice as many rockets as the Canadians, and in Canada the university usage outweighs that of the NRC scientists. A third example of a facility designed to support basic research is a number of high-resolution spectrometers and spectrographs, acknowledged to be the best anywhere.

The low-speed wind tunnel alone has been involved in the aerodynamic development of at least twenty different types of Canadian-produced aircraft, ranging from the CF-100 to the Beaver-Otter-Caribou series, for which the total sales have been estimated to exceed two billion dollars. It is still working one full shift a day exclusively for Canadian industry. In addition, the 5-foot trisonic tunnel with a speed range of Mach 0.2 to 4.5, and the hypersonic helium tunnel which will test models to Mach 17 or higher, have each proven their worth. Shortly to be commissioned is the 30-foot Vertical/Short Take-Off and Landing tunnel which is expected to be essential in developing aircraft to operate in Canada's north.

Some special-purpose facilities, such as the Seaway model and the model of the St. Lawrence River now under construction in co-operation with the Department of Transport, are designed to solve major problems of this waterway. This investment will be returned if as little as 1% of the cost of the full-scale installations can be realized as a result of the model researches. The towing tank and the ship model basin also represent other special facilities, to support research related to Canada's ship-building industry.

The major part of the physical resources of the Division of Building Research is a unified research facility to aid the Canadian construction industry. Load-measuring devices, heat and moisture transfer instrumentation, and soil testing gear represent a part of the investment for this purpose. The fire research complex, incorporating special furnaces and equipment for studying materials at high temperatures, is one of the best on the continent.

Most of the research facilities described so far are physically rather large and impressive. However, one should mention a few, at least, of the many smaller and less spectacular tools which have been developed in the laboratories and which, in gross, may have contributed just as much to Canadian science and commerce -- some of these are pocket size. Mass spectrometers

and high vacuum gauges invented in the NRC laboratories are used worldwide, and have even flown to the moon. Various electronic and mechanical instruments developed to aid medical researches have now been adopted for clinical use as well. Our techniques for building precision calorimeters are recognized to be the most advanced to date.

The Computation Centre, built around a pair of IBM 360/50's is an important facility to support many different research programs. The capabilities of the Centre are being improved as fast as available funds and people will permit, for example, the development of specialized software, but the requirements of the scientists continue to outstrip the capacity of the computers.

III-7 OTHER RESEARCH PROMOTION

Special Activities

A special activity of the National Research Council of Canada in the general area of research promotion is the support for conferences and symposia. In the past 5 years the number of conferences and symposia supported by Council are as follows:

1963-64	1964-65	1965-66	1966-67	1967-68
14	15	19	31	24

The regional distribution of these awards in the last

5 years is as follows:

West Coast	3
Prairie Regions	19
Ontario	51
Quebec	21
Maritimes	9

As an example, a typical list of conferences and symposia supported in one year is given in Appendix J.

The National Research Council of Canada awards travel grants to university staff members to assist in meeting the cost of attending conferences, meetings, symposia, normally outside of North America, or towards the cost of visiting laboratories abroad for short periods. The following shows the number of travel grants awarded in the last 5 years:

1963-64	1964-65	1965-66	1966-67	1967-68
97	140	135	226	252

Divisional Conferences

The Divisions of the National Research Council also organize conferences, symposia and seminars, in addition to those supported by the Awards Office.

The Division of Building Research has organized a total of 7 Building Science Seminars, one or two being given

each year on selected subjects. Presentations are made by Divisional staff and attract up to 500 persons interested in manufacture, construction and operation as well as design. The Division of Applied Physics sponsored three international symposia on Photogrammetry, Glacier Mappery, and Photo and Orthophoto Maps, the latter jointly organized with the Canadian Institute of Surveying. The Radio and Electrical Engineering Division has arranged 4 such symposia ranging from electrical hazards in hospitals to high voltage and have held 4 additional joint meetings with international or national organizations. In the older and more established fields of science such as chemistry, physics and biology, there are a number of general or specialized national or international societies, and the work of the Divisions can usually be presented at the annual meetings of such groups. Here the staff may be responsible for much of the organization of the meeting and most of the presentations. For example, the Division of Applied Chemistry has contributed to the meetings of the Canadian Association for Applied Spectroscopy and the Canadian High Polymer Forum. In addition, the Canadian Institute of Chemistry conferences have been supported by the Divisions of Applied Chemistry, Pure Chemistry and Biosciences. More specialized groups include the conferences of the Electrochemical Society and an international conference on Passivity in

metals. The Division of Biosciences has organized annual conferences on Cold Physiology and Plant Physiology, in addition to being major participants in such biological societies as the Canadian Society of Physiology, Canadian Biochemical Society, and the Canadian Society of Microbiologists. Upwards of 300 papers are presented annually by individual staff members at national and international conferences.

III-8 RELATIONS BETWEEN NRC AND OTHER FEDERAL DEPARTMENTS AND AGENCIES

At first glance, the scientific activities of federal government agencies may appear to an outsider to be wholly uncoordinated, and Ottawa to be a scientific jungle. This is not the case. When Council's laboratory operations were commenced, circa 1930, several departments, notably Agriculture and Mines, were already engaged in scientific research related to their missions. As NRC established its laboratories, a policy was followed not to engage in applied research work in fields already undertaken by other agencies in support of their missions.

In general, it has become accepted that any federal department or agency with a mission should be responsible for the research essential to its mission. This leaves certain fields of applied science as the territory for one single agency or department, without any uncertainty or doubt in the minds of persons in other agencies as to where the interdisciplinary

boundary fences are. There are one or two notable exceptions which are also clearly understood, for example, NRC has possessed and operated federal government wind tunnels primarily as a service to industry, but also serving Air Canada, the Department of Transport and the Department of National Defence.

It must be noted that as the size of the National Research Council's organization has expanded, portions have been detached and set up as autonomous agencies. In particular, the Medical Research Council, the Defence Research Board, Atomic Energy Control Board and Atomic Energy of Canada Limited are organizations stemming from responsibilities and activities initially carried by NRC.

Much of the co-ordination which exists is a direct outcome of good personal relationships between deputy heads of agencies and heads of scientific subdivisions. A notable example of effective co-ordination is the Canadian Committee on Oceanography, established about 1943 under the sponsorship of NRC. This Committee is self-appointed, and does not report to any Minister or agency. Its members are of deputy minister and assistant deputy minister rank from departments and agencies carrying out research activity in the field of oceanography. In particular, it makes an effort to achieve full and effective use of federal government ships and aircraft from which scientific

missions in oceanography can be performed.

The National Research Council and many other government departments from time to time establish committees usually to advise the deputy head with respect to scientific matters in the department concerned. There has always been a willingness for scientists in one department to give unstintingly of their time to serve on committees of this kind. The REVIEW of the National Research Council of Canada provides lists of Council committees on which representatives from other departments serve and the names of NRC staff members serving on committees of other departments and agencies.

IV. RESEARCH OUTPUT

IV-1 PATENTS, NEW INDUSTRIES, TECHNOLOGIES AND PROCESSES

Patents arising from research activities at the National Research Council of Canada have been directly responsible for setting up at least two fairly large industries in Canada. Research work on obtaining refractory materials from native rock deposits, on which about 80 patent applications were filed, has built an industry which has had a sales volume of approximately \$22,000,000 per year in the years 1962-67. Research work on the production of magnesium resulted in the filing of approximately 65 patent applications and the creation of another industry which has had a sales volume of approximately \$6,500,000

per year in the years 1962-67. These are two outstanding examples of the results of research having been applied to benefit the economy of Canada.

During the five-year period under review, scientists and research workers have submitted some 267 proposals for patents, on which 107 patent applications have been filed. Licenses have been granted on 34 of these inventions to 21 licensees. Royalties received indicate that the sales volume from the inventions licensed is approximately $19,000,000 for the same period.

Several companies have been formed in recent years which depend heavily on NRC inventions. For example, Guildline at Smiths Falls, Ont., established an export market based largely on their production of a precision potentiometer and other instrumentation developed at the National Research Council. The firm is now expanding its facilities to meet the coming demand for NRC-designed current and voltage comparators. As another example, Leigh Instruments of Carleton Place, Ont., has realized about $15 million to date in sales of the NRC crash position indicator -- a figure which does not include the savings in reduced costs of air-ground searches. Following successful tests of NRC's airborne radar altimeter in Canada and also over Guatemala's tropical rain forests Leigh Instruments is now

tooling up for an anticipated world-wide market for this potent aid to forest inventory and control.

The above are two examples in which the NRC's contributions form the mainstay of the company's operations. More often, the NRC's role has been to stimulate a new product or a branch operation in an established firm or industry: a few examples of this will be found in Section IV-4, "Some significant projects". While the dollar value of the NRC-inspired product would not necessarily make or break the company it can be quite appreciable in some cases, for instance, Canadian Aviation Electronics of Montreal ascribe about $9 million worth of sales to products originating from the airborne magnetometer project.

The construction industry is highly dependent on the NRC, both for innovations which instigate new products and for standards which help to stabilize existing market conditions. For example, sealed double-glazed windows are now used almost exclusively in all large commercial buildings. This is due in no small part to an NRC-developed standard of manufacture which has helped to overcome a rather chaotic situation previously arising from a very wide variation in the quality of different manufacturers' products.

Not infrequently the NRC scientists move into the company's plant to aid in establishing a new technique or to

assist in trouble-shooting an existing process. The chemical industry, perhaps more than others, has benefitted from this practice. On one occasion recently, NRC scientists carried out experiments in the smelter department of a Quebec copper firm and came up with an answer to their problem of just when to terminate the copper oxidation process for maximum efficiency. In another case, on-site calibration of the electrical instrumentation was found to be the solution at a plant where the apparatus had to operate in close proximity to very large electrical currents.

IV-2 PUBLICATIONS

During the period 1962-67 the scientific and engineering staff of the National Research Council reported the results of original research and investigation in approximately 3300 papers. The majority of these papers (approximately 90%) were published in international scientific and technical journals. The remainder appeared as bulletins in a series or as separate reports. The total figure cited above does not include a wide variety of bulletins, brochures and reports which deal with the activities and services of a specific NRC division or of the NRC as a whole.

Samples of NRC publications are listed below. A complete listing is given in Publications of the National Research Council of Canada, a computerized listing and index prepared and published by the National Science Library.

<u>NRC Review</u>. Contains reports of the directors of divisions and heads of sections and accounts of the work of the Council's committees. Includes a roster of scientific staff. Also includes a Review of the Medical Research Council.

<u>NRC Research News</u>. Quarterly news bulletin featuring selected projects of the National Research Council.

<u>Quarterly Bulletins</u> of the Division of Mechanical Engineering and the National Aeronautical Establishment and of the Radio and Electrical Engineering Division.

<u>Quarterly Progress Reports</u> of the Division of Applied Physics and the Division of Pure Physics.

<u>National Building Code</u> and <u>National Fire Codes</u>. Publications issued by NRC Associate Committees.

<u>Canadian Universities: Research in Science and Engineering</u>. 1965 Universités Canadiennes: Recherches en Sciences et en Génie. (NRC 8840). Published by the NRC Office of International Relations and Economic Studies.

<u>Annual Report on Support of University Research</u>.

<u>Graduate Students at Canadian Universities in Science and Engineering</u>. 1967-68.

Union List of Scientific Serials in Canadian Libraries. 2nd ed. 1967. 2 vols.

IV-3 PERSONNEL POLICIES OF THE NATIONAL RESEARCH COUNCIL

a) The National Research Council Act assigns to the National Research Council the responsibility for the selection and promotion of its staff. The Council's responsibility for staff matters is in turn assigned to a Standing Committee, the Board of Selection, composed of Council members. They are given full responsibility for examining all recommendations for appointment or promotion, for seeing that personnel policies laid down by the Council and the government are adhered to, and for maintaining a high standard of excellence throughout the organization. The Board meets more frequently than the Council, perhaps five or six times a year depending upon the need and submits its recommendations to the Council. Thus, the Council, is responsible for staff appointments, which is considered to be vital to the operation of a scientific laboratory.

The Director of each of the Council's Divisions is responsible for the assessment and development of his staff and for making all recommendations concerning staff to the Board of Selection. To achieve uniformity of treatment, each Director has his recommendations for appointments and promotions reviewed

by an interdivisional committee consisting of laboratory directors before presenting them to the Board. The Selection Board, has set a high standard of excellence for the Council and ensures that it is maintained.

For the purpose of evaluating scientific personnel, information on each candidate is considered under 5 main headings:

1. Factual data about the individual including such information as age, educational background and salary history.

2. The candidate's academic record. Although it does not always hold, a high scholastic record is usually directly related to high achievement in the field of scientific research.

3. The candidate's achievements in the field of science. This includes his publications and an evaluation of their quality. Patents and engineering reports are also included among his achievements.

4. Relevant experience - where the scientist or engineer has worked, on what projects, and how his experience is related to the job for which he is now being considered.

5. Confidential references from previous employers and supervisors.

Educational leave may be granted to members of the professional staff who do not have a doctor's degree but have rendered at least two years of satisfactory service in the division concerned and have demonstrated outstanding ability. An employee recommended for such leave must have academic qualifications of scholarship calibre and be considered suitable to become a continuing member of the staff. Special training leave may be granted to members of the professional staff for short terms in order that they may obtain experience and training required in connection with the research programme of the division. Postdoctorate leave may be granted to members of the scientific staff who have completed formal academic training, and who have established outstanding records of scientific achievement in the Council laboratories, for the purpose of enabling them to derive benefit from contact with research workers in other established laboratories.

Scientific staff are normally appointed on a term basis, the standard length of term being three years. This arrangement provides at regular intervals an opportunity for reviewing each employee's relationship to the work of the Council. In practice, only a very small proportion of terms are not renewed but the term appointment system, together with high standards of selection, is considered to play an important part in maintaining a research staff of high quality. Term appointees enjoy the same general benefits,

including superannuation, group medical plan, and payroll deduction privileges, as do permanent public servants.

b) Postdoctorate Fellowships

The personnel policies outlined above apply to research scientists formally appointed to the Council's staff. It should be noted however that a significant proportion of the scientific staff (in recent years approximately 20 per cent) is made up of post-doctorate fellows who have been awarded fellowships which are tenable for one year and are usually renewed for a second. The use of postdoctorate fellowships has provided, in addition to the research experience obtained by the fellows themselves, a steady turnover of keen young scientists whose diversity of training, experience and ideas has had a very stimulating effect on the research carried out in the Council's laboratories. The fellowships are open to nationals of all countries and have attracted to Canada large numbers of highly trained scientists who have then been available for recruitment by Canadian industry and universities.

A similar program of postdoctorate fellowships is administered by the National Research Council on behalf of several government departments with scientific laboratories.

c) Personnel Statistics and other Personnel Information

A variety of details relating to the nature and composition of personnel associated with scientific activities is attached in Appendix K. Also attached (Appendix L) is some information about

individuals who had the opportunity to train themselves in specialized fields with N. R. C. and who have subsequently left and made important contributions to their fields. This information is incomplete as it has not been possible to follow the paths of a number of professionals after they left the Council.

IV-4 SOME SIGNIFICANT PROJECTS

Outstanding achievements in areas of applied research and development are usually quite tangible in character, such as a piece of hardware, a process, or a compilation of technology-based information like the National Building Code. On the other hand basic research programs seem more likely to be noteworthy for the cumulative effect of a series of advances. As an example, the extensive work in our spectroscopy laboratory on determining the structures and properties of simple molecules has yielded a tremendous amount of highly significant data - in fact, it has been estimated that more than half of the total of the world's information on lighter molecules has originated in this laboratory. In a much more specialized field, NRC scientists have had until fairly recently a virtual monopoly on the observation and analysis of transient meteor spectra, a subject which has suddenly become of keen interest to space scientists studying the re-entry problem.

A recent highlight of the radio astronomy work was the successful measurement of the angular diameters of a number of

quasars, carried out by Canadian scientists by means of simultaneous observations at NRC's Algonquin Radio Observatory, E.M. & R.'s Dominion Astrophysical Observatory at Penticton, B.C., and the Jodrell Bank Observatory near Manchester, England. Worthy of remark is that not only were two government agencies and two universities (Toronto and Queen's) intimately involved, but that the job was done by an interdisciplinary group of astronomers, physicists, electrical engineers and technicians. An unexpected practical outcome of this work is the potential application of the technique to geodetic surveying.

As a by-product of their basic studies program the electron physics laboratory has produced several novel instruments for the production and measurement of high vacua, which is now of very great interest in technology and space operations. Perhaps of even greater benefit, following from this work, is the experimental extension of physical absorption isotherms well beyond previous work elsewhere, and the demonstration that these isotherms are universally applicable for the adsorption of all gases on all surfaces.

Basic research in chemical kinetics and photochemistry personally initiated by a former president of NRC (Dr. Steacie) has shed a good deal of light on the air pollution problem, and has also greatly helped the rubber, plastics, and petrochemical industries. The synthesis of several commercially important chemicals has

been made much less expensive by a process known as autoxidation. The discovery in one of our laboratories of a suitable membrane for the process of "reverse osmosis" may permit even the largest city to re-cycle its water supply.

Through the co-operative efforts of scientists at the National Research Council and Canada Department of Agriculture, rapeseed has been developed as a major crop in Western Canada. Not only has this replaced nearly 1,500,000 acres, equivalent to about 30,000,000 bushels, of wheat, with an alternative profitable crop, it provided Canada with an excellent domestic source of edible oil. This advance was made possible when NRC scientists developed procedures for providing a complete analysis of the oil in half a rapeseed, thus preserving the germ end, and enabling CDA to make appropriate selections in their breeding program. In this way erucic acid, a component of rapeseed oil considered undesirable by industry, was eliminated. Rapeseed meal provides a high protein feed for domestic animals but it contains unpalatable substances. Methods have been devised at PRL to eliminate these undesirable effects.

An airborne magnetometer has been developed, using the latest techniques of the basic physics laboratory to push the limiting sensitivity of such instruments down to less than one ten-millionth part of the earth's magnetic field. With this device extensive

surveys of the Continental Shelf have been made which have added enormously to our store of geological information and, in particular have aided the search for off-shore oil. Among other applications it has been shown that the new magnetometer should double the detection range of anti-submarine aircraft.

The absorption of sound waves in acoustic tile suggested the idea of a perforated breakwater which, it turns out, not only absorbs the incident waves almost without relfection but also induces a shoreward current to prevent the washing-out of the footings, which is a usual source of breakwater failure. The prototype full-scale installation at Baie Comeau, Quebec, based on the NRC model, has been highly successful.

Critical analysis of aerial photographs showed that perma-frost areas could clearly be distinguished by certain characteristic shadings. This has greatly speeded up preparation of a permafrost map of Canada by the Division of Building Research. DBR also came up with the answer to a costly and bothersome problem posed by the residents of the "Limestone City" (Kingston, Ontario). It was shown that the reason concrete basements, and other concrete structures exposed to damp, tend to disintegrate was that the commonly available course aggregates in the district were limestones which reacted in an unusual way with the cement to produce an undesirable expansion of the concrete. Once identified, the solution to the problem was

simply to use Portland cement with a very low alkaline content.

A listing of some highlights of our achievements should also include one or two "near misses" - projects which were scientifically successful and which appeared to have great promise for commercial exploitation but which did not quite come off, for one reason or another.

The ethylene oxide story is a case in point with many and involved ramifications which, at one phase, included the setting up of a pilot plant in our own laboratories. The new NRC technique promised to be more economical than the existing processes of oxidizing ethylene, but several attempts to introduce it to industry appear to have been frustrated in part by built-in vested interests in the older processes and in part by a lack of entrepreneurship in the licensees.

Another technological success was the NRC counter-mortar radar set, which to this day outperforms its rivals developed in the U.S.A. and U.K. In a limited sense it was a commercial success too, since ten of the units were built in Canada (Raytheon, Waterloo, Ontario) and sold to DND, while two others were sold overseas. However, despite the admitted superiority of the equipment, Canada lost the large and lucrative NATO market which would have been numbered in the hundreds of units, mainly because the final decision was not made solely on technical grounds.

V. FINANCE

Attached in Appendix M is a number of tables relating to the financial expenditures of the National Research Council over the past five years.

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Appendix A

OFFICE CONSOLIDATION

of

NATIONAL RESEARCH COUNCIL ACT

R.S.C. 1952, c. 239

as amended by

1953-54, cc. 40, 42;

1966, c. 26.

1966

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Chapter 239.

An Act respecting the National Research Council of Canada. Rep. and new. 1966, c. 26, s. 1.

SHORT TITLE.

1. This Act may be cited as the *National Research Council Act*. Short title. Rep. and new. 1966, c. 26, s. 2.

INTERPRETATION.

2. In this Act, Definitions.

(*a*) "Chairman" means the Chairman of the Committee of the Privy Council on Scientific and Industrial Research; "Chairman."

(*b*) "Committee" means the Committee of the Privy Council on Scientific and Industrial Research; "Committee."

(*c*) "company" means a company incorporated pursuant to paragraph (*a*) of subsection (1) of section 17 and any company the direction and control of which is assumed by the Council pursuant to paragraph (*b*) of subsection (1) of section 17; "Company."

(*d*) "Council" means the Council referred to in section 3; "Council." Rep. and new. 1966, c. 26, s. 3.

(*e*) "Minister" means such member of the Queen's Privy Council for Canada as may be designated by the Governor in Council to act as the Minister for the purposes of this Act; and "Minister." Rep. and new. 1966, c. 26, s. 3.

(*f*) "President" means the President of the National Research Council of Canada. "President." Rep. and new. 1966, c. 26, s. 3.

(*g*) Repealed. 1966, c. 26, s. 3.

***3.** There shall be a Council to be called the National Research Council of Canada. Council established. Rep. and new. 1966, c. 26, s. 4.

* Note: The corporation called The Honorary Advisory Council for Scientific and Industrial Research and the National Research Council of Canada are declared for all purposes to be one and the same corporation.

Wherever in any Act, order, regulation, deed, contract, lease or other document, the Honorary Advisory Council for Scientific and Industrial Research is mentioned or referred to, there shall, in each and every case, be substituted the National Research Council of Canada. (1966, c. 26, ss. 12 and 13.)

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Committee on Scientific and Industrial Research. Rep. and new. 1966, c. 26, s. 4.

4. There shall be a committee of Ministers to be called the Committee of the Privy Council on Scientific and Industrial Research, consisting of a Chairman to be nominated by the Governor in Council, the Minister, and such number of other members of the Queen's Privy Council for Canada as the Governor in Council may determine, to be nominated by the Governor in Council.

Appointment of Council.

5. (1) The Council consists of a President, a Vice-President (Administration) and two Vice-Presidents (Scientific) and not more than seventeen other members, to be appointed by the Governor in Council.

Tenure of office. Rep. and new. 1966, c. 26, s. 5.

(2) Each member of the Council, other than the President, the Vice-President (Administration) and the Vice-presidents (Scientific) shall be appointed to hold office for a term of not more than three years.

Re-appointment.

(3) A retiring member is eligible for re-appointment.

Executive Committee.

(4) There shall be an Executive Committee of the Council consisting of the President, the Vice-President (Administration), the Vice-Presidents (Scientific), and at least three other members selected by the Council.

President of the Council.

6. (1) The President is the chief executive officer of the Council and has supervision over, and direction of, the work of the Council and of the officers, technical and otherwise, appointed for the purpose of carrying on the work of the Council.

Vice-President (Administration).

(2) Subject to the direction and control of the President, the Vice-President (Administration) has charge of all matters relating to administration and shall perform such other duties as the President may from time to time assign to him.

Vice-Presidents (Scientific).

(3) Subject to the direction and control of the President, each of the Vice-Presidents (Scientific) has supervision over such scientific matters and shall perform such other duties as the President may from time to time assign to him.

Salaries as prescribed by Governor in Council.

(4) The President, the Vice-President (Administration) and the Vice-Presidents (Scientific) shall receive such salaries and be employed for such terms of office as the Governor in Council may prescribe, and such salaries shall be paid out of moneys provided for the work of the Council.

Duties of Council. Rep. and new. 1966, c. 26, s. 6.

7. The Council has charge of all matters affecting scientific and industrial research in Canada that may be assigned to it by the Committee.

Council incorporated. Rep. and new. 1953-54, c. 42, s. 1.

8. (1) The Council is a body corporate, capable of suing and being sued and having power to acquire and hold real and personal property for the purposes of and subject to this Act.

(2) Repealed. 1966, c. 26, s. 7.

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9. (1) The Council is for all purposes of this Act an agent of Her Majesty and its powers under this Act may be exercised only as an agent of Her Majesty. Agent of Her Majesty.

(2) Actions, suits or other legal proceedings in respect of any right or obligation acquired or incurred by the Council on behalf of Her Majesty, whether in its name or in the name of Her Majesty, may be brought or taken by or against the Council in the name of the Council in any court that would have jurisdiction if the Council were not an agent of Her Majesty. Proceedings by and against the Council.

10. The Council shall meet at least three times a year in the City of Ottawa on such days as are fixed by the Council and at such other times and places as the Council deems necessary. Meetings. Rep. and new. 1953-54, c. 42, s. 2.

11. The Executive Committee of the Council may exercise the powers of the Council and shall submit at each meeting of the Council minutes of its proceedings since the last preceding meeting of the Council. Powers of Executive Committee.

12. (1) No member of the Council, with the exception of the President, the Vice-President (Administration) and the Vice-Presidents (Scientific) shall receive any payment or emolument for his services, but each member shall receive such travelling and other expenses in connection with the work of the Council as may be approved by the Governor in Council. Travelling and other expenses.

(2) Notwithstanding subsection (1), a member of the Council other than the President or a Vice-President may, for any period during which he performs with the approval of the Council any duties on behalf of the Council in addition to his ordinary duties as a member thereof, be paid such remuneration as may be authorized by the Council. Remuneration of members for additional duties. New. 1966, c. 26, s. 8.

13. Without thereby limiting the general powers of the Council conferred upon or vested in it by this Act, it is hereby declared that the Council may exercise the following powers, namely: Powers of Council.

(*a*) to make by-laws for the conduct of its business;

(*b*) to control and direct the work of the Council through the President, and, in case of the illness, absence or suspension of the President, or in the case of vacancy in the office of President, through an Acting President temporarily appointed by the Council;

(*c*) to undertake, assist or promote scientific and industrial research, including, without restricting the generality of the foregoing, Amended. 1953-54, c. 42, s. 3(1).

(i) the utilization of the natural resources of Canada, Rep. and new. 1953-54, c. 42, s. 3(1).

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(ii) researches with the object of improving the technical processes and methods used in the industries of Canada, and of discovering processes and methods that may promote the expansion of existing or the development of new industries,

(iii) researches with the view of utilizing the waste products of said industries,

(iv) the investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy, and the determination of physical constants and the fundamental properties of matter,

(v) the standardization and certification of the scientific and technical apparatus and instruments for the Government service and for use in the industries of Canada, and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service,

(vi) the investigation and standardization, at the request of any of the industries of Canada, of the materials which are or may be used in, or of the products of, the industries making such a request, and

(vii) researches, the object of which is to improve conditions in agriculture;

(*d*) to have charge of, and direction or supervision over, the researches which may be undertaken, under conditions to be determined in each case, by or for single industrial firms, or by such organizations or persons, as may desire to avail themselves of the facilities offered for this purpose;

Rep. and new. 1966, c. 26, s. 9(1).

(*e*) to expend, for the purposes of this Act, any money appropriated by Parliament for the work of the Council;

New. 1966, c. 26, s. 9(1).

(*ea*) to acquire any money, securities, or other property by gift, bequest or otherwise, and to expend, administer or dispose of any such money, securities or other property subject to the terms, if any, upon which such money, securities or other property is given, bequeathed or otherwise made available to the Council;

Rep. and new. 1966, c. 26, s. 9(2).

(*f*) with the approval of the Minister, to appoint such scientific, technical and other officers as are nominated by the President, to fix the tenure of such appointments,

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to prescribe the several duties of such officers, and, subject to the approval of the Governor in Council, to fix their remuneration;

(*fa*) to authorize the President or any other officer of the Council to appoint persons to perform duties of a temporary nature for a period not exceeding six months; New. 1966, c. 26, s. 9(2).

(*fb*) to establish, operate and maintain a national science library; New. 1966, c. 26, s. 9(2).

(*g*) subject to the approval of the Minister, to publish and sell or otherwise distribute such scientific and technical information as the Council deems necessary; Rep. and new. 1966, c. 26, s. 9(2).

(*h*) to carry on work and manufacturing of an experimental and developmental nature with respect to the matters referred to in paragraphs (*c*) and (*d*) so as to render the processes, methods or products to which the said matters relate more available and effective in useful arts and manufacturing and for scientific purposes and otherwise; and

(*i*) to license, sell or otherwise grant or make available to others, Canadian or other patent rights or any other rights, vested in or owned or controlled by the Council, to or in respect of any discovery, invention or improvement in any art, process, apparatus, machine, manufacture or composition of matter, and to receive royalties, fees and payments therefor.

***14.** The Minister may authorize the President to approve on his behalf the publication, sale or other distribution by the Council of scientific and technical information. Delegation. New. 1966, c. 26, s. 10.

15. All receipts and expenditures of the Council are subject to examination and audit by the Auditor General. Audit of expenditures.

* Note: The previous sec. 14, which was repealed by 1953-54 c. 40, sec. 15, provided:

"(1) Every discovery, invention or improvement in any art, process, apparatus, machine, manufacture or composition of matter made by a member or any number of members of the scientific and technical staff of the Council or a company and all rights with respect thereto are vested in the Council.

(2) The Council, with the approval of the Governor in Council, may pay to its scientific and technical officers and to others working under its auspices who have made any valuable discovery, invention or improvement in any art, process, apparatus, machine, manufacture or composition of matter, such bonuses or royalties as in its opinion may be warranted. 1950, c. 21, s. 7."

The *Public Servants Inventions Act*, chapter 40 of the Statutes of 1953-54, which was proclaimed in force as of the 1st day of June, 1955, repeals section 14. The Act, however, applies only to inventions that were made, or for which an application for a patent was made, after June 1st, 1954. Section 14, therefore, remains in force for all prior inventions.

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Annual report. Rep. and new. 1966, c. 26, s. 11.

16. The President shall, within four months after the termination of each fiscal year, transmit to the Minister a report of the operations of the Council for that fiscal year and the Minister shall cause such report to be laid before Parliament within fifteen days after the receipt thereof, or, if Parliament is not then sitting, on any of the first fifteen days next thereafter that Parliament is sitting.

17. (1) The Council may, with the approval of the Governor in Council,

Council may procure incorporation of companies.

(*a*) procure the incorporation of any one or more companies under the provisions of Part I of the *Companies Act*, for the objects and purposes of exercising and performing on behalf of the Council such of the powers conferred upon the Council by paragraphs (*c*), (*d*), (*h*) and (*i*) of section 13 of this Act as the Council may from time to time direct and all the issued shares of the capital stock of each such company shall be owned or held in trust by the Council for Her Majesty in right of Canada except shares necessary to qualify other persons as directors; or

Assume control of existing companies.

(*b*) assume, by transfer to the Council in trust for Her Majesty in right of Canada of all the issued share capital thereof except shares necessary to qualify other persons as directors, the direction and control of any one or more existing companies incorporated under the provisions of Part I of the *Companies Act* all the issued share capital of which is owned by or held in trust for Her Majesty in right of Canada except shares necessary to qualify other persons as directors and may delegate to any such company any of the powers conferred on the Council by paragraphs (*c*), (*d*), (*h*) and (*i*) of section 13 of this Act.

Books and records.

(2) Every company shall keep and maintain such books and records, in addition to those required by the *Companies Act* as the Council may prescribe and shall make such reports and returns to the Council as the Council may require.

Accounts.

(3) The accounts of a company shall be audited by the Auditor General.

Appendix B

NATIONAL RESEARCH COUNCIL OF CANADA

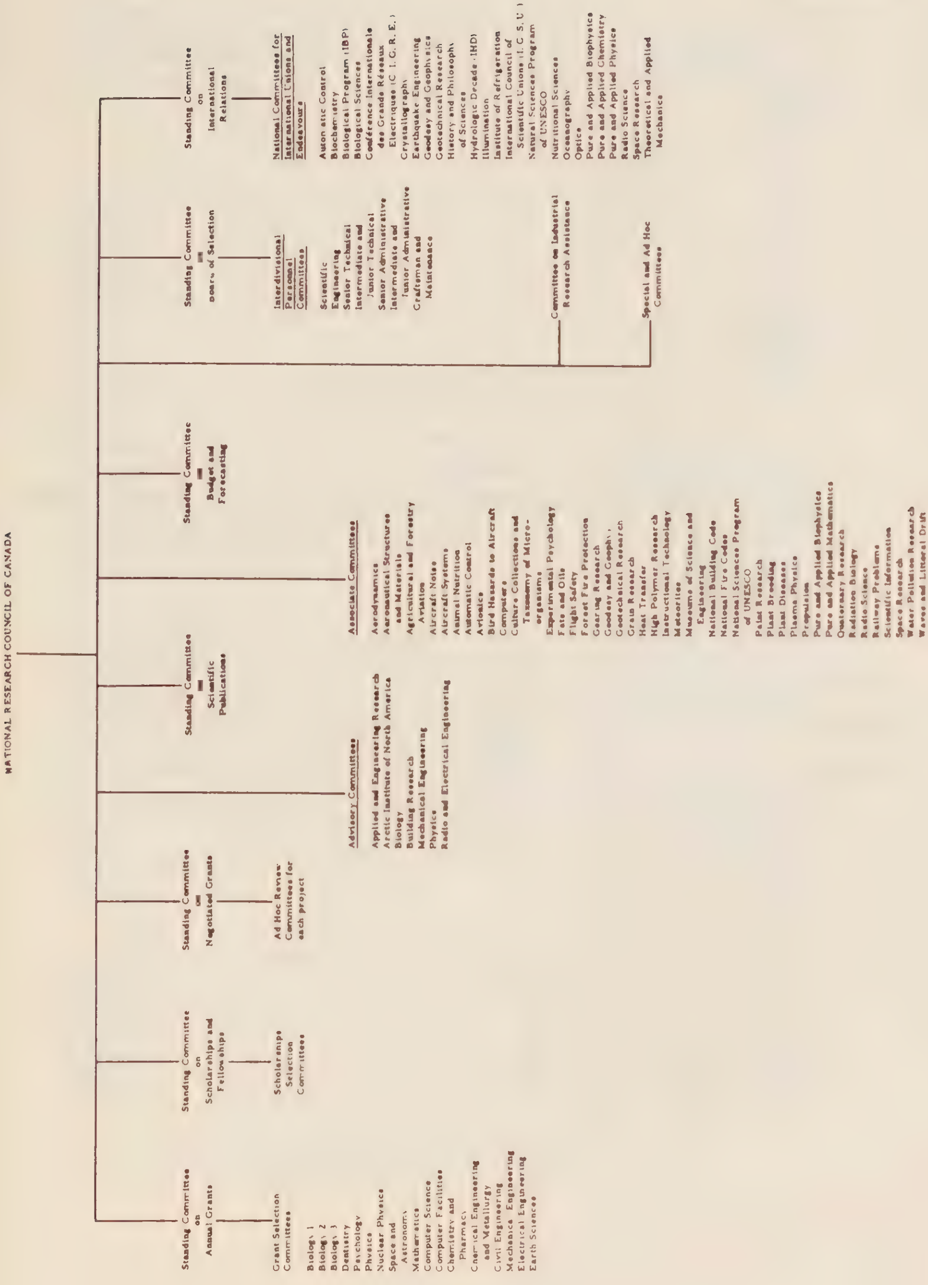
PRESIDENT

DELEGUE-GENERAL	EXECUTIVE DIRECTOR (LABORATORIES)	VICE-PRESIDENT (SCIENTIFIC)	VICE-PRESIDENT (SCIENTIFIC)	VICE-PRESIDENT (ADMINISTRATION)
Dr. L. G. Cook	Dr. D. W. R. McKinley	Dr. W. H. Cook (ACTING)	Dr. K. F. Tupper (ACTING)	Dr. K. F. Tupper
Program Analyses Policy Review Economic Studies	Applied Chemistry Applied Physics Atlantic Regional Laboratory Biosciences Building Research Mechanical Engineering National Aeronautical Establishment Prairie Regional Laboratory Pure Chemistry Pure Physics Radiation Biology Radio and Electrical Engineering Space Research Facilities Branch	Awards Program for Support of University Research Canadian Journals of Research International Relations Associate Committee Secretariat	Industrial Research Assistance Technical Information Service (Ottawa) Technical Information Service (Field Ops)	Administration & Personnel Administrative Planning Service Computation Centre Financial Services General Counsel National Science Library

FOOTNOTE: In addition to the five positions at the Vice-Presidential level, the President also has the following positions reporting directly to him:- Executive Assistant, Chief of Information Services, and the Secretary of the Council.

13. 9. 68

Appendix C


NATIONAL RESEARCH COUNCIL OF CANADA
Standing Committee on Annual Grants
Grant Selection Committees
Biology 1
Biology 2
Biology 3
Dentistry
Psychology
Physics
Nuclear Physics
Space and Astronomy
Mathematics
Computer Science
Computer Facilities
Chemistry and Pharmacy
Chemical Engineering and Metallurgy
Civil Engineering
Mechanical Engineering
Electrical Engineering
Earth Sciences
Standing Committee on Scholarships and Fellowships
Scholarships Selection Committees
Standing Committee on Negotiated Grants
Ad Hoc Review Committees for each project
Advisory Committees
Applied and Engineering Research
Arctic Institute of North America
Biology
Building Research
Mechanical Engineering
Physics
Radio and Electrical Engineering
Standing Committee on Scientific Publications
Associate Committees
Aerodynamics
Aeronautical Structures and Materials
Agricultural and Forestry Aviation
Aircraft Noise
Aircraft Systems
Animal Nutrition
Automatic Control
Avionics
Bird Hazards to Aircraft
Computers
Culture Collections and Taxonomy of Micro-organisms
Experimental Psychology
Fats and Oils
Flight Safety
Forest Fire Protection
Gearing Research
Geodesy and Geophysics
Geotechnical Research
Grain Research
Heat Transfer
High Polymer Research
Instructional Technology
Meteorites
Museums of Science and Engineering
National Building Code
National Fire Codes
National Sciences Program of UNESCO
Paint Research
Plant Breeding
Plant Diseases
Plasma Physics
Propulsion
Pure and Applied Biophysics
Pure and Applied Mathematics
Quaternary Research
Radiation Biology
Radio Science
Railway Problems
Scientific Information
Space Research
Water Pollution Research
Waves and Littoral Drift
Standing Committee on Budget and Forecasting
Standing Committee on Board of Selection
Interdivisional Personnel Committees
Scientific
Engineering
Senior Technical
Intermediate and Junior Technical
Senior Administrative
Intermediate and Junior Administrative
Craftsman and Maintenance
Committee on Industrial Research Assistance
Special and Ad Hoc Committees
Standing Committee on International Relations
National Committees for International Unions and Endeavours
Automatic Control
Biochemistry
Biological Program (IBP)
Biological Sciences
Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.)
Crystallography
Earthquake Engineering
Geodesy and Geophysics
Geotechnical Research
History and Philosophy of Sciences
Hydrologic Decade (IHD)
Illumination
Institute of Refrigeration
International Council of Scientific Unions (I.C.S.U.)
Natural Sciences Program of UNESCO
Nutritional Sciences
Oceanography
Optics
Pure and Applied Biophysics
Pure and Applied Chemistry
Pure and Applied Physics
Radio Science
Space Research
Theoretical and Applied Mechanics

Appendix D

GRANTS TO UNIVERSITIES

	National Research Council				
	Scholarships and Fellowships	Research Grants	Facilities	Other	Totals
		($ Millions)			
1963-64	2.6	8.0	1.7	0.5	12.8
1964-65	3.1	11.9	1.9	0.5	17.4
1965-66	4.3	15.2	2.0	0.6	22.1
1966-67	5.5	24.6	3.7	0.8	34.6
1967-68	6.9	31.3	6.1	1.5	45.8

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National Research Council of Canada: Fifty Years of Scholarships

B. A. Gingras, F.C.I.C.
Awards Office
National Research Council
Ottawa
T. W. West
Personnel Services
National Research Council
Ottawa

EIC-67-EDUC 4
Issued as N.R.C. No. 9619

To mark the fiftieth anniversary of the National Research Council of Canada's scholarship program, which coincides with Canada's Centennial, a survey of all NRC scholarship recipients during the period 1917-1966 was conducted, with a view to tracing the careers of these recipients subsequent to their awards. Questionnaires were sent to 94% of award holders and about 90% returned the completed questionnaires from 46 countries.

In the overall program the Council awarded some 11,000 scholarships with a total value of $17 million to 5,378 individuals. At the inception of its scholarship program in 1917 the Council awarded nine scholarships to promising young graduate students; this year the Council awarded 2,171 scholarships, with a value of $6,562,200.

Of the total sample, 91.2% were male and 8.8% female. Of the scholars 75.6% were born in Canada, 2.5% in the United States, 6.6% in the United Kingdom, and 15.3% in other foreign countries.

Table I shows the distribution by field of study for the Bachelor's degree.

Table I

Distribution of all NRC Scholars by Field of Bachelor's Degree 1917-66

Field of Study	Percent
Chemistry and Chemical Engineering	28.4
Engineering	18.1
Biological Sciences	17.7
Physics	15.3
General Sciences	8.4
Mathematics	7.0
Earth Sciences	3.5
Psychology	1.6

For purposes of analysis the total group has been subdivided into the five samples shown in Table II.

Table II

Distribution of all NRC Scholars by Work Status 1917-66

Current Work Status	Number
Professionally employed	2,395
Students	1,964
Retired	81
Housewives	71
Others	12

The latter three groups will not be examined in detail because they are relatively small. Eighty-one of the former scholarship holders have retired. Three of them hold a Bachelor's degree, 24 a Master's degree and 54 a Doctor's degree, of whom seven have had postdoctorate training. The oldest living scholarship holder was born in 1887. Their employment orientation upon retirement is shown in Table III. Of the 71 housewives, four hold a Bachelor's degree, 42 have a Master's degree and 25 have a Ph.D. Of the latter, 11 have had postdoctorate experience. 62% of the housewives are located in Canada and 31% in the United States.

Table III

Retired Sample Distribution by Employment Orientation upon Retirement

Orientation	Percent of the Retired Sample
Teaching	29.0
Basic Research	21.0
Research and Development Management	17.7
Applied Research and Development	9.7
General Management	9.7
Prevention and Treatment of Diseases	6.5
Production	3.2
Others	3.2

Of the twelve people who reported a work status other than student, professionally employed, housewife, or retired, four were unable to work at their profession because of ill health, two were farming, one was a missionary, and five were unemployed.

Student Sample

Figure 1 shows the growth of the awards program from 1917 to 1967. It shows why, from a sample of 4,500 covering a period of 50 years, over 40% (1,964) are shown as currently being students. The average age of the student group, however, is 26 with only 10 of the group being over 35 years of age.

Analysis of this group by the highest degree held shows that 972 hold a Bachelor's degree, 789 a Master's degree, and 203 a Doctor's degree of whom 117 have done some postdoctorate work.

Ninety percent of the students are men. Seventy-one percent were born in Canada, two percent in the United States, seven percent in the United Kingdom and twenty percent in other foreign countries.

Professionally Employed Sample

The most interesting information to come from a survey such as this deals with the group that is currently professionally employed. Data on this group, representing several fields of employment and many geographic locations, provide an opportunity to look at such things as migration, job orientation, employment field, and salary levels.

There were 2,395 people in this category, 95% were male, 3% married female, and 2% single female; 78.9% were Canadian born, 2.6% U.S., 6.1% U.K., and 12.4% were born in other foreign countries.

The average age of the group was 39. The rapid growth of the program in recent years explains the relatively youthful age of the group (Fig. 1). Three percent of the sample held only a Bachelor's degree, 20% a Master's, and 77% a

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The Journal of the Engineering Institute of Canada

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Ph.D. Of the latter group, slightly over one-third had postdoctorate training.

Table IV shows the percentages of the professionally employed sample holding a Bachelor's degree in the fields indicated.

Table IV

Professionally Employed Sample Distribution by Field of Bachelor's Degree

Field	Percent
Chemistry	31.6
Engineering	16.4
Physics	14.9
General Sciences	10.1
Life Sciences	7.8
Mathematics	5.6
Earth Sciences	3.8
Agriculture	3.2
Animal Sciences	2.7
Plant Sciences	2.3
Psychology	1.6

Employment Orientation

In the questionnaire each respondent was asked to identify his main employment orientation. In the final tabulation, teaching accounted for 31.6%, basic research 29.4%, applied research and development 16.4% and research and development management 10.4%, with 12.2% distributed over the five remaining orientation choices.

When the individual's first and second orientations were scanned simultaneously, basic research led with 61% stating that either main or second employment orientation was in this field. The only other orientation that approached the level of basic research was teaching, which was a main or second orientation reported by 45% of the sample.

It is of interest here to compare the reported relationship between teaching and basic research. From a total of 702 reporting basic research as their main orientation, 261 reported that their second orientation was teaching (35.8%) From a total of 753 reporting teaching as their main orientation, 568 reported that their second orientation was basic research (75.4%).

As might be expected, the highest proportion of those reporting a second employment orientation occurred with the teachers (83%).

An analysis of the main employment orientation for each of the three major fields of employment: government, industry, and education is given in Table V.

It may be easily seen here that each of the fields dominates one employment orientation: basic research in government, applied research in industry, and teaching in education.

Employment Location

With the great amount of current discussion on scientific migration and the "brain drain", it was of interest to examine employment location and change of location in some detail.

Table V

Professionally Employed Sample Distribution by Employment Orientation for Three Main Employment Fields

Employment Orientation	Government %	Industry %	Education %
Research and Development Management	12.4	24.0	1·6
General Management	5.3	9.8	3.0
Basic Research	53.4	17.5	24.2
Applied Research	21.8	36.9	1.9
Teaching			68.3

As a starting point, the professionally employed sample was analyzed in terms of the location of present employment. The result is shown by country in Table VI, and by province in Table VII.

Table VI

Professionally Employed Sample Distribution by Country of Employment—July-December 1966

Country	Percent of Sample
Canada	74.2
United States	20.8
United Kingdom	1.9
France	0.3
Other	2.8

Table VII

Professionally Employed Sample Employed in Canada—July-December 1966

Comparison of distribution of NRC Scholars with general population distribution for Canadian Provinces (1961 census)

Province	Percent of NRC Scholars in Province	Percent of overall population of Canada located in Province
British Columbia	9.4	9.0
Alberta	6.7	7.4
Saskatchewan	4.7	5.0
Manitoba	3.4	5.0
Ontario	48.9	34.1
Québec	21.2	28.9
New Brunswick	1.9	3.2
Nova Scotia	3.1	4.0
Prince Edward Island	0.1	0.6
Newfoundland	0.6	2.6
Yukon-Northwest Territories	0.1	0.2

Examination by province indicates that the ratio of scholars employed in British Columbia and Ontario is above the general population ratio while in all other provinces it is below.

If the sample is examined by location of bachelor graduation, the ratios shown in Table VIII are obtained.

Table VIII

Professionally Employed Sample Distribution of Sample by Province of Bachelor Graduation

Province of Bachelor Graduation	Percent of Sample
British Columbia	13.2
Alberta	5.7
Saskatchewan	9.3
Manitoba	7.1
Ontario	32.0
Québec	21.7
New Brunswick	5.0
Nova Scotia	5.9
Newfoundland	0.1

When comparing this table with Table VII, it is interesting to note that British Columbia, Saskatchewan, Manitoba, New Brunswick and Nova Scotia have all graduated a higher ratio of scholars than their general population ratio but none has been able to employ as high a ratio as it trains. Ontario, it would appear, is the only province that is able to hire a greater ratio than it trains. Quebec is very close to breaking even as it granted Bachelor's degrees to 21.7% and employs 21.2% of the total sample.

A natural question concerns the percentage of those currently employed in the province where they received their Bachelor's degree. Quebec, possibly because of cultural ties, leads in this respect. Sixty-two percent of those located in Quebec received their Bachelor's degree there. For British Columbia, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia the ratio is approximately 45%, and in Alberta 23%. The numbers employed in the remaining provinces are too small to permit comparisons.

Migration

Thirty-six percent of those in the professionally employed group indicated that they had made a major change in employment location during their careers. Most of the changes reported were from one province to another, or one country to another.

The greatest number of country-to-country changes occurred between Canada and the United States. However, this analysis shows that the migration was not at all unilateral. Most dissertations on the "brain drain" refer to an irreplaceable loss of Canadian scientific talent to the United States. Our information would indicate that this is not the

case. The results of this survey show that of the group reporting location changes, 38.0% had moved from Canada to the United States, while of these, one-third had returned to Canada.

Extrapolation of this fact indicates that while, at any given point in time, 20.8% (see Table VI) of our scientific talent is employed in the United States, one-third of them are in fact gaining valuable training and experience which they will eventually bring back to Canada. At the present time the net loss would be about 14%. A number of respondents added notes to their questionnaires stating that they had returned to Canada in spite of the fact that the move cost them several thousand dollars in annual salary.

The highest proportion of changes were reported from province to province within Canada (41.1%), with only minor movement (approximately 3% each) reported from Canada to the United Kingdom, the United Kingdom to Canada, Canada to other, and the United States to the United States. Without exception the migration question showed more people moving from any given Canadian province than moving to it.

Employment Field

Respondents were asked to indicate whether their sphere of activity could be classed as government, industry, education, or other. The resulting distribution is shown in Table IX.

Table IX

Professionally Employed Sample Distribution of Sample by Current Employment Field

Field	Percent of Sample
Government	25.3
Industry	25.5
Education	45.5
Other	3.7

Those indicating "other" were working mainly in the consulting field with a few working for private research organizations.

Of the total professionally employed sample 21.1% indicated that in the course of their careers they had made a major change in field. Forty percent had left government; thirty percent industry; and twenty-five percent education.

The field of education benefitted the most from those who left government and industry, with two-thirds of the government and industry people moving into education. Of those leaving the field of education, 39% went to government, 51% to industry, and 10% to other fields.

Two-thirds of those who had made a change in field also had made a major

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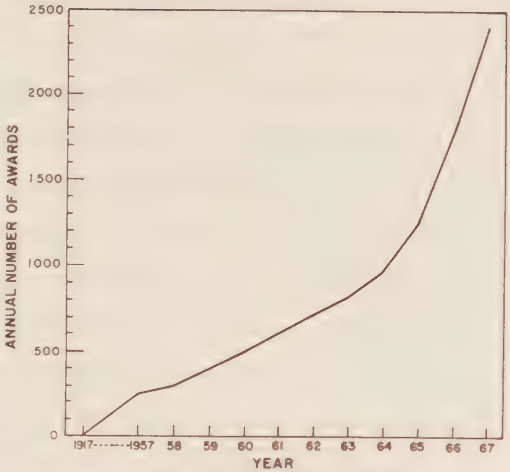
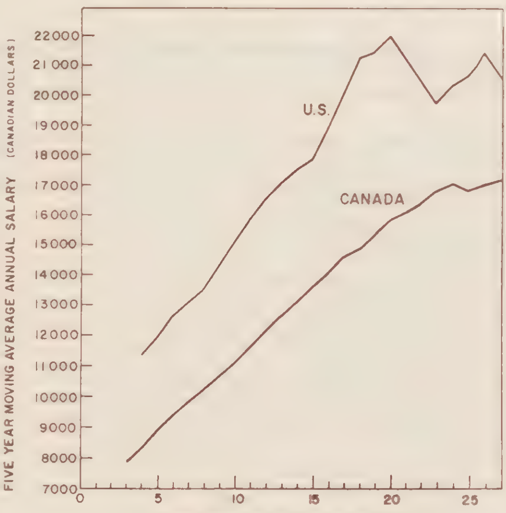
GROWTH OF THE N.R.C. SCHOLARSHIP PROGRAM

1917-1967



CANADA-U.S. SALARY COMPARISON



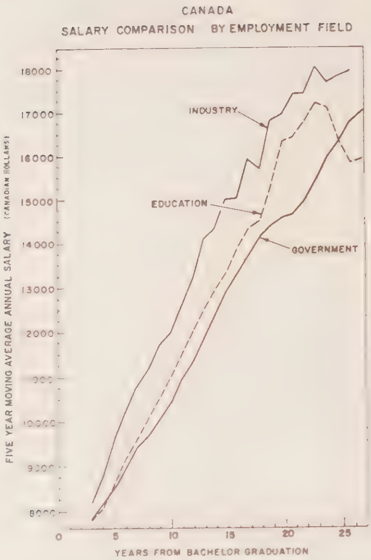


Fig. 3.

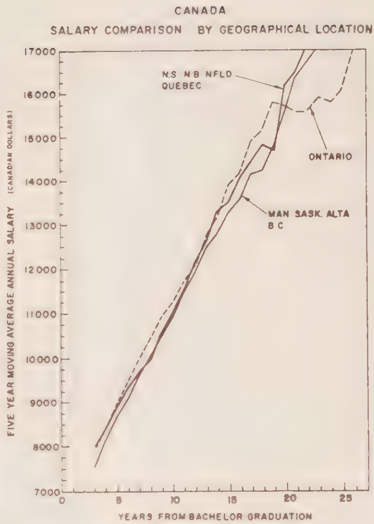


Fig. 4.

change in location. No information was gathered on whether these changes were made simultaneously.

Salary Levels

The questionnaire asked each respondent to give the total of his annual earned income, including stipends, bonuses, etc., and asked for these figures in Canadian dollars. Over 96% of the respondents were kind enough to provide this information. These salaries ranged from a low near $4,000 to a maximum near $100,000, with year of bachelor graduation going as far back as 1918.

Canadian salary data were first compared with those of the United States and then were broken down by field and by location and analyzed separately.

The resultant salary distributions were smoothed by calculating the 5-year centred moving average and then plotting this against number of years from bachelor graduation.

(For any one year, the 5-year moving average is calculated by determining the mean salary for that year, adding to it the mean salaries for each of the two years immediately preceding and the two immediately following, and dividing by five.)

In Fig. 2, the 5-year moving average annual salaries for Canada and the United States are compared. It is easily seen that for individuals of similar qualifications the salary difference is of the order of $3,000-$6,000 Canadian.

The salaries of those currently employed in Canada were examined in more detail. As shown in Fig. 3 salaries were analyzed for the three major employment fields. The industry group leads for the entire 24 year range by amounts varying from $500 to $1,500.

University and government salaries are quite close for the first few years, but the university group increases more rapidly and leads for the largest part of the range. Only at maturity levels beyond 23 years does the university curve begin to drop off and is overtaken by the relatively steadily increasing government curve.

To obtain salary data by employment location the sample was divided into three geographic sections. a) Quebec, the Maritimes and Newfoundland; b) Ontario; and c) Manitoba, Saskatchewan, Alberta and British Columbia. These curves plotted in Fig. 4 are almost coincident. It should be noted however that for the Quebec, Maritimes and Newfoundland curve the indicated distribution is heavily weighted with the salaries of those employed in Quebec and does not accurately reflect Maritimes and Newfoundland salaries. All curves increase steadily over the first 20 years of the range at which point the slope of the Ontario curve tends to drop off. Comparison with Fig. 3 would lead us to conclude that the Ontario curve for 20 to 25 years from bachelor graduation reflects the result of a majority in that range being employed in the field of education.

Acknowledgments

The authors wish to thank Drs. F. T. Rosser and J. B. Marshall without whom this survey would not have been possible. Thanks are also due to K. J. Mintha for clerical assistance.

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INDUSTRIAL RESEARCH ASSISTANCE PROGRAM

The concept of IRAP was based on a memorandum 'Federal Support on Industrial Research in Canada" dated 19 October 1961 from Dr. Steacie, then President of N. R. C., to the Committee of the Privy Council on Scientific and Industrial Research. This presented a consensus of the views of a number of senior executives and scientists in research-oriented government departments and industry as to the relatively small research effort in non-defence areas of Canadian industry, and the proposed plan for building it up. The Committee recommended the basic proposal to Cabinet and the program was authorized by Cabinet Decision dated November 27, 1961, incorporated later in Privy Council Order 691 dated 14 April 1965. See Attachment 1.

N. R. C. was given the responsibility for administering the Program and a Committee on Industrial Research Assistance (CIRA) was organized to review applications and establish operational policies. An organizational block diagram is shown in Attachment 2. The Chairman and Secretariat are from N. R. C. and the members from government departments and agencies concerned with industrial research, production, marketing and finance. They include Atomic Energy of Canada Limited, the departments of Energy, Mines and Resources, National Defence, Industry, Trade and Commerce, and Treasury. The members are at deputy minister level or equivalent and meet as necessary to consider major changes in policy. Otherwise, senior executives from their departments attend the regular meetings of CIRA held every four to six weeks to consider applications.

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These members also provide cross representation from the Defence Industrial Research Program (DIR) of National Defence, and the Program for Advancement of Industrial Technology (PAIT) of Industry and Commerce. Liaison is also maintained secretarially with the Defence Development Sharing Program (DDSP) and the Industrial Research and Development Incentive Act (IRDIA) Program in Industry and Commerce, to avoid duplication or overlapping.

The N. R. C. Committee on Applied Science and Engineering Research, consisting of senior executives from industry, university and government, advises the Council on overall policy governing IRAP and industry itself makes direct representation to the Council, CIRA and the government.

Proposals from companies may be presented throughout the year and are reviewed for suitability by the Secretariat, composed of N. R. C. staff possessing scientific degrees and some industrial experience. Every assistance is given to companies to present a sound proposal and to ensure it is placed in the most appropriate departmental program. The proposals are assessed as to their scientific content, their feasibility and the quality of professional personnel by scientific advisors to the Committee. These are Directors of N. R. C. divisions or other government laboratories, who also nominate senior scientists from their staffs to act as Liaison Officers on approved projects.

Liaison officers officially make only one visit per year to assess and report on company progress although companies are encouraged to use their knowledge and government laboratory facilities as needed. Their reports and company reports are used by the Committee when considering the annual renewal of grants. Over 100 liaison officers and many other government scientists have

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been associated with 131 companies over periods of three to five years, leading to improved communications between government and industrial scientists and a better understanding of industrial research needs.

In recent years support has been given to university professors participating directly in IRAP projects or providing guidance leading to the upgrading of competency of research teams. This also leads to better communication between industrial and university scientists and a feedback which may affect university teaching and research. 31 companies presently have 41 professors associated with them, and 42 university students were supported this year to expose them to industrial research careers.

The Program is experimental in nature and considerable flexibility is exercised by the Committee in adjusting guidelines and ground rules to meet industrial needs as they develop, both in long term policy and on the merits of each case. Every effort is made to avoid red tape, unnecessary conditions and restrictions, and supervision, direction or policing of projects. All proposals are considered, and decisions reached within three months of submission, on an average.

The technical background of a company, its record of competence and quality, its continuity of interest in research, and the technical capabilities and accomplishments of its staff are considered in the selection process.

The potential affect on Canadian production and exports, and the general commercial soundness of proposals also are considered, although the company's willingness to share half the cost is taken as strong evidence in this regard.

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Projects which have a bearing on industry-wide or national problems, in addition to company interest, such as the economic utilization of industrial wastes as by-products, reduction of water pollution, lowering of consumer costs, and meeting of higher standards in domestic and foreign specifications, are given favourable consideration. Large companies wishing to undertake more sophisticated applied research are encouraged to do so.

Companies that are small, new to research or located in the Western and Maritime provinces are treated more flexibly to encourage their participation and regional development.

Until the current year 1968/69, sufficient funds have been available to support all suitable proposals. Proposals now awaiting further funding have been given a priority rating by the Committee after weighing the above factors. Under these circumstances, the committee tends to support companies new to research rather than companies already receiving support, other considerations being equal.

Companies renew their applications each year, at which time they may propose changes in staffing, scope or the objectives of the project, although this also can be done, if essential, at any time. The Committee assesses progress and approves continuation as requested, or on a conditional basis subject to improvement in company performance.

Either party may terminate projects at any time, the Committee generally doing so because of poor performance, the company because of changes in company policy or economic conditions and difficulties in financing or staffing a project. Time is allowed for the project to be wound up and staff to transfer.

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The success of IRAP is measured by its effectiveness in establishing competent research teams and the creation or expansion of scientific and technical expertise in companies, primarily to innovate and secondarily to provide back-up support to development and production teams. Accordingly the Committee requires that an IRAP project and the people in it are readily identifiable as such. This creates some administrative difficulties in larger companies but not of a major nature.

The complete impact of IRAP on the Canadian economy will not be felt for some years, but several companies have produced commercial products and processes, as well as scientific papers and patents. The Secretariat attempts to keep a general record of this but the information is not readily obtainable and is difficult to evaluate in dollars and cents.

Considerable statistical data has been recorded as to the numbers and background of scientists in IRAP and the distribution of grants by industrial fields, size of companies and geographical areas. Attachment 3 includes some of this material.

In 1965, 138 U. S. A. companies reported R&D expenditures of 10 million dollars or more, including 29 companies over 100 million dollars. A comparison (1968 figures) with a medium-size U. S. A. research laboratory, Ford Motor employing 385 professionals with a 14 million dollar budget of which one half is for salaries, Northern Electric's central laboratory in Ottawa employing 216 professionals in applied research with a 7. 6 million dollar budget, and IRAP supporting 450 professionals with a combined company-government budget of 15. 2 million dollars, shows the respective costs per professional in Canadian dollars as $39, 300, $35, 200 and $33, 800.

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Although showing that IRAP costs are in line, this comparison also illustrates the gap between the U. S. A. and Canadian research effort.

The Committee has been able to operate effectively within its present terms of reference, responsibilities and authority. Administration is simple and, until the current year, funding has been adequate. Acceptance of the program by industry, in general, has been most favourable although some companies feel they should have much more freedom to spend the grants as they see fit within their total research organization, a thought more related to the successful development of a product than the objectives of the program. Accordingly it is felt that the growth of the program has been governed by the shortage of senior scientists, the time required to build and equip laboratories, and the availability of company funds to invest in IRAP rather than by any limitations imposed on the Committee.

However, the overall expenditure in industrial research in Canada still is generally regarded as undesirably low. If IRAP is to increase its contribution towards this goal, more government expenditure will be required to match the further expenditure from the private sector. The Council and its Advisory Committees have also considered various possible ways of broadening the concept of IRAP. These include such measures as the support of research in research organizations, either of their own initiation or on behalf of companies, the support of operational or systems research projects, and the contracting of government research requirements such as reduction of pollution, forest fire protection, etc. to commercial research or manufacturing organizations.

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EXTRACT FROM DR. STEACIE'S MEMORANDUM DATED SEPTEMBER 1961

TO THE COMMITTEE ON THE

PRIVY COUNCIL ON SCIENTIFIC AND INDUSTRIAL RESEARCH

THE NECESSITY FOR FEDERAL GOVERNMENT ASSISTANCE

There is no question that Canadian industry is not spending the same relative amount of money on research as is the case in the United States and United Kingdom. On the other hand, perhaps the most striking discrepancy is the relatively small amount of Government financing of research performed in industry as shown in Table 6. Here Canada is low by a factor of between 10 and 20. The reason for this is a quite simple and quite logical one because of the very large scale development of expensive weapons in the United States and United Kingdom. A very large amount of research is carried out in industry in these countries under Government development contracts. With the relatively small amount of development of new weapons in Canada it is obvious that the Government has not the same need for such contracts. In spite of this, contracts via the Department of Defence Production, Defence Research Board and Atomic Energy of Canada Limited are of appreciable magnitude. There is no question that such development contracts have been placed in the United Kingdom and in United States primarily for defence purposes and to fill a specific need. On the other hand, they have carried with them an enormous bonus in the building up of research facilities in British and American industrial firms and this has resulted in a very large amount of increased spending by industry itself. It seems unlikely that further tax concessions or exhortation of industry will produce an increase of any appreciable magnitude in the spending by private industry for research and it seems certain that the only way in which the situation can be rectified is by some form of direct Government financial aid. On the other hand, there is no question that any financial aid given to industry to expand its research facilities and performance must be on a selective and matching basis. No permanent impression will be made on industry unless it is spending its own money on research.

HOW CAN FEDERAL FINANCIAL AID BE USED TO STIMULATE INDUSTRIAL RESEARCH?

To a degree an increase in development contracts as at present carried out under the auspices of the Department of Defence Production, the Defence Research Board and Atomic Energy of Canada Limited cannot fail to have a beneficial effect. However, it would appear that direct aid to companies

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xpanding research for their own purpose is essential. If such aid is given it is very important that it be given through a source experienced in the problems of supporting research rather than through a high-level council of industrialists who might well have little experience in industrial research. In fact one of the main problems is to convince management of the need for industrial research. If Federal funds are to be awarded in the form of grants there will certainly be many difficulties in administration. The body administering the grants must pick and choose among firms making submissions, must try to sell the program to firms capable of making use of it, and must be able to assess the scientific feasibility of the project, and above all the attitude of management. Actually the problems are not too different from those associated with making "grants in aid" to universities and in view of the National Research Council's 45 years of experience along these lines, it is recommended that any scheme of industrial research grants be set up under the National Research Council. If such a policy were adopted the Council would, of course, set up a variety of advisory committees with representatives from industry and other federal Government organizations to help in making decisions. It is, of course, possible to set up the scheme with responsibility placed in the hands of other Government organizations, and the interests of the Treasury and the Department of Trade and Commerce must be considered. However, our experience in handling "grants in aid" has convinced us of the desirability of placing responsibility for the success of the program firmly in the hands of one organization, even if much power is delegated to coordinating or advisory committees.

The experience of those agencies which have given out development contracts has shown that there is a great deal of difficulty in monitoring such contracts in a detailed financial way. If assistance is being given for projects of the industry's own choice these difficulties will become even greater. The only successful method of operating such a scheme would be to avoid driving a hard bargain, since this will not be attractive to industry and since it will almost be impossible to sort out real costs. At the same time it is essential that roughly half the cost be borne by industry itself. It is suggested that an easy way to do this would be for the Government to agree to finance salaries and wages for expanded research programs, and to leave it to industry to pay all equipment and overhead costs. This would probably work out at an approximately equal distribution of expenditures. It is suggested that such grants be on an outright basis, and that there should be no strings on patent rights, etc.

It is, therefore, recommended that the Government take as a long-range objective the matching of industrial research expansion up to say a limit of \$50,000,000 or \$100,000,000 a year to be reached within five to ten years, and that this develop somewhat slowly at the start. If anything along these lines is done it is essential that it be on a long-range basis, and there must be continuity. The industry must be assured that provided the work done is good, aid will be forthcoming over a period of from five to ten years, since a team cannot be built

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up in an atmosphere of uncertainty. Also the terms of such grants must be carefully defined so as to exclude market research, technical sales and minor types of product development for specific customers. In short, the aim must be to build up real and permanent applied research and development competence rather than customer service or trivial modification of gadgets or products.

This memorandum is the result of discussions with a variety of Government agencies concerned with research and with a number of senior executives in Canadian industry. The ideas are in particular the joint ones of Dr. C.J. Mackenzie, Dr. A.H. Zimmerman, Dr.J.L. Gray and myself. We all feel it is important that something be done to improve the Canadian position in industrial research. There has been much discussion going on about this. Briefs are being submitted by various organizations to the Glassco Commission and elsewhere and it is felt that it would be highly desirable for the Government to take positive action now rather than to defer action until it is forced into some sort of industrial research support in a rush. It is necessary certainly to proceed somewhat slowly. However, the matter has been under discussion for a long time and we appear to be gradually arriving at a fair degree of unanimity as to what is necessary and how it should be carried out. It is important that no further delays should occur and that something should be done immediately to offset our grave deficiencies in research in industry. The whole thing must be tackled on somewhat the same basis as the university grants of the National Research Council when they were started 45 years ago. We must aim at building up real technological competence in Canada and it is essential to recognize that this can only be done by continuous support and that it will be five or more years before the impact on our economy will be fully realized.

THE TIMING OF THE PROGRAM

The limiting factor in the development of such a program is the availability of staff. This means two things: the recruiting of experienced people, say from 30 years of age and up, and the hiring of recent graduates with master's or doctor's degrees. In both fields there will be difficulties. The whole object of the scheme is to increase the number of research workers in Canada. Nothing will be gained if companies recruit staff mainly by taking them away from other companies, Government laboratories, or universities. As a result it would be unwise, and in fact impossible to proceed too fast. For this reason, it is felt that a maximum of $2,000,000 could be used in the first year, although it would be helpful to be able to make commitments for the following years. It is therefore recommended that a sum of $2,000,000 be made for the first year on the understanding that supplementary estimates might be submitted if the program went exceptionally well. In view of the negotiations required to get things started no provision need be made for the remainder of the current fiscal year, but it would be essential to be able to make commitments for 1962-63 immediately. The requirements in further years would depend on the rate of development of the program. It is suggested that eventually $5,000,000 to $10,000,000 a year in new grants might be awarded. This would mean an annual Government commitment which would rise to $50,000,000 to $100,000,000 per year.

E.W.R. Steacie, President,
National Research Council.

September, 1961.

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Attachment 1 (A)
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MEMORANDUM TO CABINET

At a meeting on October 2, 1961, the Committee of the Privy Council on Scientific and Industrial Research considered a submission on government aid to stimulate research and development in industry. ("Research and development" is being used here in such a way as to exclude technical sales, market research, minor product changes, etc.)

(1) It was the unanimous opinion of the Committee that the relative magnitude of the research effort carried out in the laboratories of industrial firms in Canada was far below that in the United States and the United Kingdom; and that not only was industry itself spending less on research, but also that the government financing of research and development in industry is, relative to Gross National Product, below that in the United States and the United Kingdom by a factor of 15 to 20.

(2) It was agreed that financial assistance by the government was essential to stimulate a build-up of competent research teams in industry. It was also agreed that further progress cannot be made by tax concessions, and that some form of direct financial assistance was essential.

(3) If such aid is given it is essential that:

(a) It should be on a matching basis with industry contributing at least half the cost of any project.

(b) There should be a reasonable assurance of continuity so that research teams may be built up.

(c) That projects submitted by industry should be judged on their merits and on the competence of the existing or proposed staff. Any across-the-board scheme would be too expensive, and would defeat its own purpose. The purpose of the scheme is to establish a number of competent research teams in industry each year over a 10 year period. If this can be done the whole complexion of Canadian industrial research will be changed.

(d) That decisions on the award of financial aid be made by committees of people competent in applied research and development.

(e) That projects should preferably be those in which industry is itself interested, and that all rights arising out of the work done be the property of the company concerned. Unless a generous attitude in this regard is taken it is unlikely that industry will be interested in accepting aid.

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Attachment 1 (A)
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(f) That such a program must be built up carefully because of the necessity of recruiting competent staff without disturbing other work which is already in progress, and also to surmount the very considerable administrative difficulties envisaged.

(g) That industry be consulted on detailed matters of procedure before any scheme is initiated.

(4) To give effect to the above considerations it is recommended:

(a) That the program be initiated immediately under the National Research Council on an experimental basis. The Council would appoint committees of experts from other government organizations and from industry.

(b) That a sum of $2,000,000 be made available to the National Research Council for this purpose in 1962-63 estimates.

(c) That industry be invited to apply to the National Research Council for research assistance for specific projects of interest to themselves. Tentatively it is proposed that such assistance be on a matching basis with the government paying salaries and wages and industry paying all other costs.

(d) If the scheme is a success its fairly rapid expansion would be contemplated.

Appendix F
Attachment 1 (B)

RECORD OF CABINET DECISION

Meeting of November 23rd, 1961.

Government aid to stimulate research and development in industry

The Cabinet agreed that financial assistance be made available for research by industrial firms in Canada on the following basis:

(a) the assistance would be on a matching basis, with industry contributing at least half the cost of any project;

(b) the general purpose of the scheme would be to establish a number of competent research teams in industry each year over a period of years, and the research and development projects submitted by industry should be judged on their merits with this general purpose in mind;

(c) that a sum of $1,000,000 be provided for this purpose in the 1962-63 estimates of the National Research Council;

(d) that the programme be initiated by the National Research Council on an experimental basis after consultation with industry on matters of procedural detail;

(e) that decisions on the award of financial aid be made by committees of people competent in applied research and development, and that as necessary the Council should establish committees of experts from departments or agencies of the government and from industry; and,

(f) that rights arising out of the research projects would be the property of the company concerned.

Registrar of the Cabinet.

Privy Council Office,
November 27th, 1961.

P.C. 1965-691

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Attachment 1 (C)
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CANADA

PRIVY COUNCIL

AT THE GOVERNMENT HOUSE AT OTTAWA

WEDNESDAY, the 14th day of APRIL, 1965.

PRESENT:

HIS EXCELLENCY

THE GOVERNOR GENERAL IN COUNCIL.

His Excellency the Governor General in Council, on the recommendation of the Chairman of the Committee of the Privy Council on Scientific and Industrial Research, pursuant to any enactment of the Parliament of Canada for defraying the several charges and expenses of the public service from and after the first day of April, 1965, that provides for payments in respect of Assistance Towards Research in Industry, is pleased hereby to approve the following terms and conditions which are to govern the National Research Council's industrial research assistance program:

1. Financial assistance is to be given to assist industry in establishing competent research teams for relatively long-term applied research projects in science and engineering which offer reasonable potential for achieving major advances.

2. Assistance is to be confined to companies incorporated in Canada and to research to be carried out in Canada.

3. Financial assistance is to be granted to companies only after their applications have been approved by the Committee on Industrial Research Assistance of the National Research Council.

4. The costs of projects are to be shared on the basis of approximately equal contributions by the National Research Council and industry.

... 2

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5. Grants are to be made annually on a fiscal year basis, subject to the provision of funds by parliamentary vote, and any unspent balance is to lapse at the end of the fiscal year.

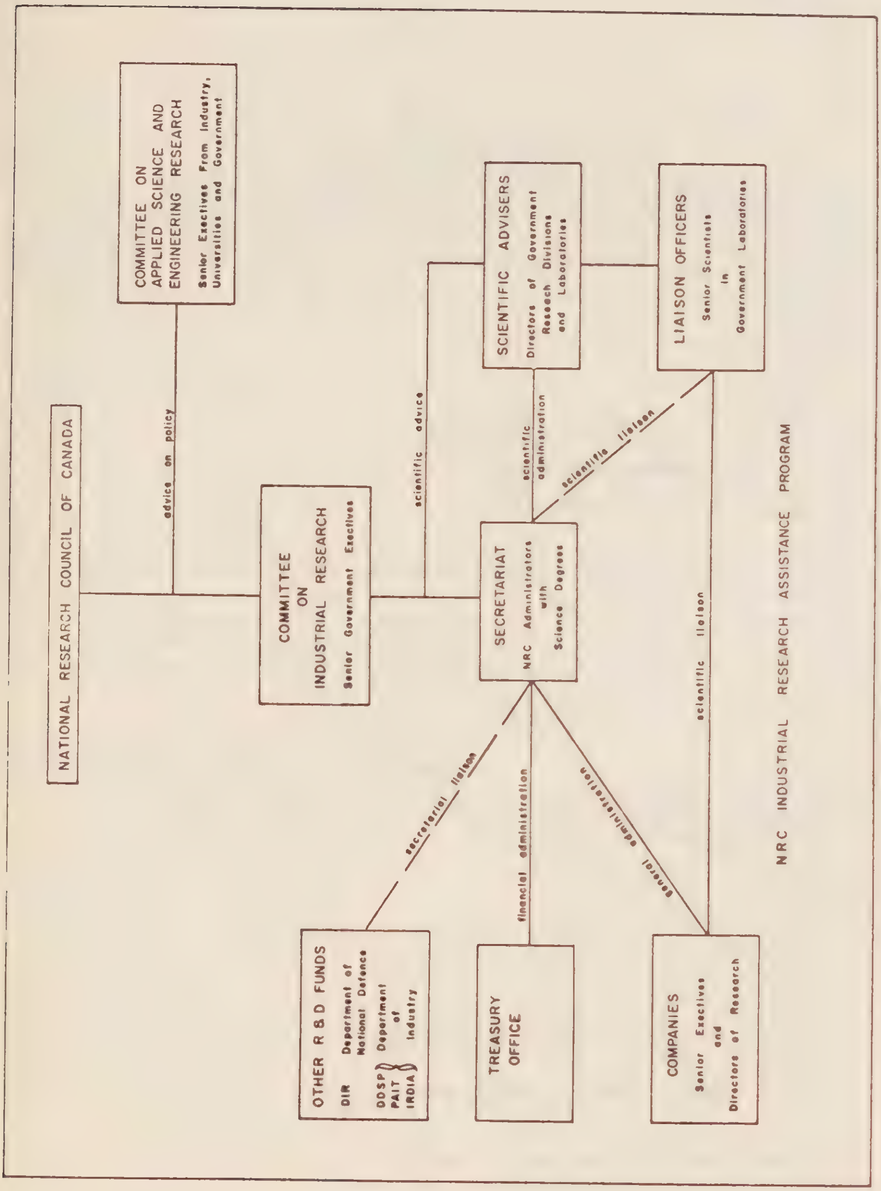
6. Matters of administrative procedural detail are to be determined by the Committee on Industrial Research Assistance and the National Research Council.

7. No patent or property rights shall accrue to the Government of Canada as a result of a research project.

CERTIFIED TO BE A TRUE COPY

CLERK OF THE PRIVY COUNCIL

Appendix F
Attachment 2



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- 1 -

GROWTH OF PROGRAM

N.R.C. INDUSTRIAL RESEARCH ASSISTANCE PROGRAM

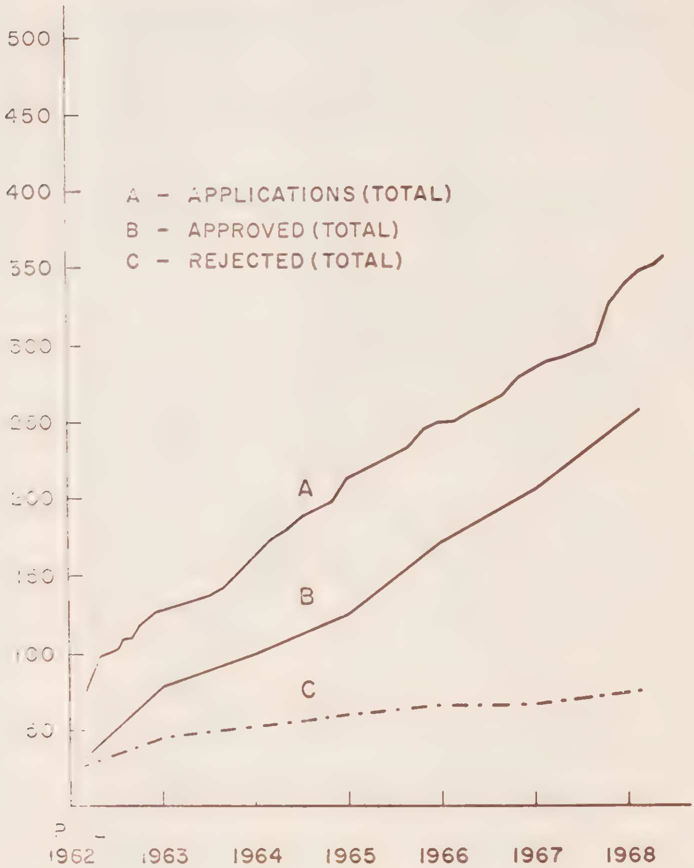

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TABLE 1

CUMULATIVE TOTALS OF COMPANIES RECEIVING GRANTS
BY
SIZE OF COMPANY AND GEOGRAPHICAL DISTRIBUTION

April 1962 to September 1968

PROVINCE	199 or Less Employees	200 to 299 Employees	1000 or More Employees	Total Companies	Associations	Overall Total
B.C.	2	2	5	9	1	10
ALTA	3	1	3	7	2	9
SASK	1	0	0	1	0	1
MAN	2	1	0	3	1	4
ONT	31	10	28	69	1	70
QUE	9	9	15	33	3	36
N.B.	0	1	1	2	0	2
TOTALS	48	24	52	124	8	132
PERCENTAGES	39%	19%	42%	100%		

TABLE 2

APPLICATIONS FOR ASSISTANCE (BY FISCAL YEAR)

	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69 (To July 1968)
Received	124	30	57	38	34	54	10
Withdrawn by Company	1	2	4	5	1	0	0
Pending	-	-	-	-	-	1	2
Reviewed	123	28	53	33	33	54	8
Approved	78	22	44	27	32	47*	6
% Approved	63%	79%	83%	82%	97%	87%	75%

(*2 subject to availability of funds 1968/69)

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TABLE 3

FINANCIAL SUMMARY

FUNDS APPROVED	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69 (To July 1968)
Commitment Authority	-	-	3,000,000	4,500,000	6,000,000	6,900,000	7,300,000
Funds Provided	1,200,000	2,400,000	2,700,000	3,500,000	4,500,000	5,700,000	6,100,000
Committed	843.922	2,093,100	2,981,233	4,246,500	5,293,600	6,361,600	7,147,400
Expended	537,318	1,603,605	2,171,269	3,306,262	4,198,994	5,036,849	
Percentage	64%	77%	73%	78%	79%	80%	
Renewals	-	1,646,100	2,440,400	3,543,900	4,604,000	5,487,450	6,233,400
No. of Renewals		60	79	105	122	122	138

TABLE 4

AVERAGE ANNUAL COSTS OF PROJECTS

	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69 (To July 1968)
Average Grant	13,500	25,000	26,800	30,000	35,100	42,400	41,600
Est. Company Cost	13,400	24,900	33,500	39,300	41,700	56,600	53,300
Total	26,900	49,900	60,300	69,300	76,800	99,000	94,900
Actual NRC Support	8,700	19,100	19,200	23,500	27,800	32,000	-
Actual Company Costs	14,800	23,500	30,300	32,600	41,700	43,000	-
Total	23,500	42,600	49,500	56,100	69,500	75,000	-
Maximum Annual Grant	70,300	99,700	115,000	147,500	215,000	322,000	292,800
Minimum Annual Grant	6,000	6,000	3,900	4,200	4,700	5,800	7,900
Est. Months Duration		37	42	52	50	55	58

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TABLE 5

TOTAL PROGRAM

DATE	NO. PROJECTS	NRC SUPPORT	COMPANY COSTS	TOTAL
1 Jun 1963	74	7,412,000 (51%)	7,193,000 (49%)	14,605,000
1 Jun 1964	98	11,200,000 (47%)	12,675,000 (53%)	23,875,000
1 Apr 1965	122	13,314,305 (46%)	15,601,198 (54%)	28,915,503
1 Apr 1966	159	19,389,826 (44%)	24,454,346 (56%)	43,844,172
1 Apr 1967	188	22,962,895 (44%)	29,001,404 (56%)	51,964,299
1 Apr 1968	223	30,594,767 (42%)	41,540,436 (58%)	72,135,203
1 Jul 1968	254	37,293,331 (43%)	49,544,197 (57%)	86,837,528
ACTIVE -				
1 Jul 1968	172	32,474,232 (43%)	42,508,803 (57%)	74,982,535
COMPLETIONS AND TERMINATIONS TO DATE (1 July 1968)				
	80	4,819,099 (41%)	7,035,894 (59%)	11,854,993

Note: 68 of the 131 companies involved in IRAP were new to research and 44 of them currently in IRAP have created 300,000 sq. ft. of laboratory space, employ 197 professionals including 52 Ph. D. 's, and are spending a total of 6 million dollars on applied research in 1968/69.

The remaining 43 companies had previous research experience. Between January 1962 and December 1967 they have expanded laboratory space from 930,000 to 1,650,000 sq. ft. (77%), increased total capital investment in research buildings and equipment from 31. 3 million dollars to 74 million dollars (136%), increased annual research operating expenditures from a total of 25. 3 million to 58. 6 million dollars (135%).

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TABLE 6

ANNUAL GRANTS ($000's)

ACTIVE PROJECTS

INDUSTRY	1962/63 1963/64	1964/65	1965/66	1966/67	1967/68	1968/69*
FOOD & BEVERAGE	325.5	290.1	399.7	447.4	619.7	642.6
RUBBER	189.0	215.0	290.0	474.2	558.0	575.9
TEXTILE	28.5	61.6	115.7	114.0	57.9	88.0
WOOD	63.2	128.0	175.8	205.0	231.4	239.5
PAPER & ALLIED INDUSTRIES	198.1	149.5	204.1	475.1	776.6	865.1
PRIMARY METALS	202.3	282.1	356.0	272.5	346.1	342.9
METAL FABRICATING	128.2	104.5	36.2	24.4	70.6	139.4
MACHINERY	128.3	112.1	232.7	379.5	400.4	361.8
TRANSPORTATION EQUIPMENT	31.4	36.6	36.5	-	-	80.8
ELECTRICAL PRODUCTS	511.1	433.0	578.9	655.6	674.8	860.3
NON-METALLIC MINERALS	154.8	118.6	214.2	276.3	435.2	404.2
PETROLEUM & COAL PRODUCTS	71.1	54.5	101.3	111.2	110.7	141.4
CHEMICAL & CHEMICAL PRODUCTION	532.0	529.5	877.1	1063.8	1190.8	1345.8
PHARMACEUTICALS	311.0	394.6	495.2	645.0	698.3	875.4
OTHER MANUFACTURING	62.7	71.5	133.1	149.6	191.2	184.3
TOTAL	2937.2	2981.2	4246.5	5293.6	6361.7	7147.4

Note: IRAP companies are mostly in fields other than aircraft and electronics, whose applications are directed generally towards DIR and PAIT.

65% of IRAP funds have gone to the chemical, rubber, drugs, petroleum, food, paper and wood industries. In 1965, this represented over 90% of the government applied research support received by these industries.

* July 1968

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TABLE 7

TOTAL POSITIONS
(for current projects only on date shown)

Date	Professional	Technician	Student	Total
1 June 1963				
Created	200	121	-	321
Filled	143 (71%)	88 (72%)	-	231 (72%)
1 June 1964				
Created	266	176	-	442
Filled	214 (80%)	162 (92%)	-	376 (85%)
1 October 1965				
Created	389	294	-	683
Filled	286 (76%)	209 (75%)	-	495 (75%)
1 September 1966				
Created	412	316	-	728
Filled	357 (87%)	271 (86%)	-	628 (86%)
30 June 1967				
Created	431	357	33	821
Filled	377 (87.5%)	312 (87.4%)	28 (85.7%)	717 (87.3%)
30 June 1968				
Created	505	395	49	949
Filled	448 (88.7%)	346 (87.6%)	34 (69.4%)	828 (87.3%)

Note: 705 professional and 541 technician positions have been created by IRAP. DBS reports show that scientists and engineers engaged in applied research increased from 1148 in 1963 to 1673 in 1965, an increase of 45.5% as compared to 1.8% in basic research and 7.7% in development. IRAP contributed one-third of this 45.5% increase.

DBS reports also show that Ph.D.'s engaged in R&D in manufacturing industries increased from 514 in 1961 to 739 in 1965, a total of 225 of 44%. IRAP companies accounted for 125, of which 90 were supported by IRAP. IRAP projects now support 140 Ph.D.'s, an increase of 55% in 2½ years.

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TABLE 8

ORIGIN OF PERSONNEL ENGAGED ON SUPPORTED PROJECTS

	30 June 1967		30 April 1968	
Transfer from within firm	246	(34.4%)	288	(38.2%)
Recruit from Canadian industry	138	(19.2%)	153	(20.4%)
Recruit from U.S. industry	13	(1.8%)	9	(1.2%)
Recruit from U.K. industry	18	(2.5%)	23	(3.1%)
Recruit from other industry	29	(4.0%)	39	(5.2%)
Recruit from University	172	(24.0%)	162	(21.5%)
Recruit from Technical Institute	32	(4.5%)	32	(4.2%)
Recruit from School	29	(4.0)	19	(2.5%)
Origin unknown	40	(5.6%)	28	(3.7%)
TOTAL	717		753	

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LISTING OF RESEARCH PROJECTS

To accomplish its goals the NRC has one program covering all matters related to science and engineering. This program is supported by four main activities or sub-programs which, though separable in principle, are to some extent intermeshed. These are respectively, assistance to the universities, assistance to industry, general administration and promotion in support of research, and intramural research.

This Appendix lists the intramural projects of the Divisions which together make up the sub-program of intramural research. Included in the compilation, of course, are a number of projects in which the intramural activity interacts more or less strongly with the university and industrial programs.

There are a number of ways in which the information could be tabulated. It could be done by discipline but modern research methods tend to blur the conventional lines between disciplines. One might better attempt to trace the thread of an identifiable activity through the disciplinary and administrative structure. This is not always an easy exercise, though it is

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actually being followed in the current re-alignment of intramural activities. We should eventually be in a position to present our program in such a manner. For the present, though, a listing by Divisions as they are now constituted seems to be a reasonable and useful compromise.

The internal structure of most of the Divisions is made up of groups of research workers known unofficially as Sections. Usually a Section will be involved in one specific and identifiable part of the Division's activity, though it is not uncommon for several more or less loosely related projects to be going on within a given Section. Co-operative and complementary projects are often undertaken involving two or more Sections, either within the same Division or in different Divisions. The administrative structure in NRC is largely vertical, but the control and guidance of the scientific program is both vertical and horizontal.

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APPLIED CHEMISTRY

Division of Applied Chemistry

Analytical Chemistry

(a) Emission spectroscopy of inorganic materials

(b) Gas chromatographic and infrared analysis of organic mixtures

(c) Analytical chemistry of thorium and associated rare earths

(d) Ion exchange resins and spectrophotometric methods in inorganic analysis

(e) X-ray fluorescence inorganic analysis

Chemical Engineering

(a) Separation of suspended solids in liquids by inclined settling and spherical agglomeration

(b) Separation of substances in solution by membrane permeation

(c) Studies on physical and chemical properties of fluidized and spouted beds

(d) Solid state inorganic chemistry

(e) Separation of solids in packed fluidized beds

Colloid Chemistry

(a) Dielectric properties of polar molecules

(b) Applications of differential vapor pressure measurements

(c) Stability characteristics of suspensions

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Corrosion

(a) Oxidation of metals

(b) Electrochemistry of corrosion

(c) Electron Diffraction and microscopy

(d) Metallography

High Polymer

(a) Ionic and radical polymerization mechanisms

(b) Characterization of polymer solutions

(c) Lignin reinforcement of rubbers

(d) Molding and testing of rubbers

High Pressure

(a) P.V.T. properties of vapors and liquids

(b) Accurate measurement of high pressures

(c) Chemical kinetics

(d) Properties of high pressure phases (dielectric, X-ray, thermodynamics, etc.)

(e) Far infrared spectroscopy

Hydrocarbon Chemistry

(a) Oxidation of liquid hydrocarbons

(b) Reactions of phenols and amines with peroxy radicals

(c) Organic synthesis

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Kinetics and Catalysis

(a) Atomic and free radical reactions in the vapor phase

(b) Catalytic processes in hydrocarbon chemistry

(c) Electron spin resonance spectroscopy

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APPLIED PHYSICS

Division of Applied Physics

High Temperature Research

Determination and analysis of the transport properties of solids at high temperatures.

Acoustics

(a) Noise control in industrial machines

(b) Audiometric techniques and calibration

(c) Acoustic absorbers

(d) Hearing conservation – ear defended development

(e) Studies of molecular structure using ultrasonic methods

Standards

The development and maintenance of calibration services in the fields of acoustics, colorimetry, electricity, mechanics (length, mass, hardness, etc.), optics, temperature, time, X-ray and nuclear radiations.

Neutron Physics

(a) Development of neutron source standard

(b) Studies of energy distribution from radioactive neutron sources

Photogrammetry

(a) Systematic investigation of limiting factors in photogrammetric accuracy

(b) Application of digital techniques to the analysis of aerial photographs

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A P P L I E D P H Y S I C S

Photogrammetry (cont'd.)

(c) Development of Analytical Plotter and of a precise monocomparator

(d) Development of a system for the production of orthophotographs. Includes a new type of orthoprojector, contouring table and facilities for automatic contouring and shading.

Radiation Exposure Measurements

Development of equipment for measuring low and medium energy x-rays and gamma-rays and development of a total energy calorimeter for Cobalt 60 sources

Optics

Research on photometry and color vision; design and calibration of instrumental optics; diffraction optics, aimed at enhancing instrument resolution.

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Atlantic Regional Laboratory

The following projects are basic in nature, but are grouped under headings which indicate the field in which application may occur.

Food Production

(a) Chemistry of seaweed polysaccharides; cultivation and drying of seaweeds

(b) Ecology, biochemistry, and physiology of marine algae

(c) Taxonomy of peat mosses; biosynthesis of lichens

(d) Production of toxic substances by fungi isolated from Nova Scotian pastures

(e) Biosynthesis of lignin and related compounds

(f) Growth of phytoplankton organisms in pure culture

(g) Photosynthesis by marine algae

(h) Metabolism of aromatic compounds by higher plants

Medicine

(a) Chemistry of psychotomimetic compounds

(b) Chemistry of aminochromes and catecholamines

(c) Biosynthesis of antibiotics by actinomycetes

(d) Spectral studies of hydration of ribonucleic acids

(e) Metabolic control of biosynthesis in fungi

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ATLANTIC REGIONAL LABORATORY

Chemical Industry

(a) Studies of liquid silicates and molten salts at high temperatures

(b) Kinetics of decarbonization of liquid iron-carbon alloys and of liquid iron-sulphur alloys

(c) Synthesis of aromatic compounds by the Diels-Adler process, and temperature effects in the substitution reactions of aromatic compounds

(d) Reactivities of the hydroxyl groups of carbohydrates

(e) Hydrogen bonding in ice and water

(f) Electrochemical studies on inorganic compounds at high temperatures

(g) Determination of gases in metals by isotopic dilution

(h) Determination of the structures of natural products by spectroscopic methods

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BIOSCIENCES

Division of Biosciences

Food Research

(a) Effects of freezing and storage on the biochemistry and quality of foods

(b) Refrigerated transport

(c) Chemistry of milk

(d) Meat biochemistry

(e) Fluoride in food

(f) Fat chemistry

Biometrics

(a) Agrometeorological studies

(b) Sensory comparison tests

(c) Numerical taxonomy of bacteria

Animal Physiology

(a) Acclimatization to cold

(b) Physiology of flight in birds

Plant Physiology

(a) Photosynthesis

(b) Translocation of photosynthetic products

(c) Toxic algae

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BIOSCIENCES

Chemistry of Natural Products

(a) Properties of polysaccharides of plant origin

(b) Polysaccharides of microbial origin – relation between chemical structure and immunological reactions

(c) Lipids of plants

Cell Biology

(a) Morphogenesis of plant cells

(b) Production of biological fibres – celluloses, chitin and keratin

(c) Structure and synthesis of plant cell components

(d) Organization and development of yeast cell wall

(e) Structure of ribosomes

(f) Effects of freezing on cellular components

Protein Studies

(a) Egg-yolk proteins

(b) Blood lipoproteins and glycoproteins

(c) Protein synthesis

(d) Structure of hemoglobin

(e) Glycoproteins from plasmas

Microbiology

(a) Structure and metabolism of halophilic and psychrophilic bacteria, and of yeasts

(b) Lipids of microorganisms

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Microbiology (cont'd.)

(c) Proteases of microorganisms

Radiation Biology

Effects of ionizing radiations on animal cells

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BUILDING RESEARCH

Division of Building Research

Building Materials Research

(a) Paints and protective coatings

(b) Concrete, unit masonry and mortar

Building Services

Environmental aspects — heating, cooling and humidity control, together with mechanical services including water and drainage system.

Building Structures

Studies of buildings in relation to snow and wind loads, and assistance in preparing codes and standards.

Building Physics

Applications of physics to building problems, with emphasis on vibrations and acoustics

Fire Research

Studies of combustion of materials, fire behaviour in buildings, extinguishment of building fires

Snow and Ice

Studies of formation, growth and break-up of ice as it affects buildings, harbors, bridges, towers, etc.

Soil Mechanics

Studies of the fundamental behaviour of soils, and investigation of improved foundation design and construction techniques

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B U I L D I N G R E S E A R C H

Building Practice

(a) The provision of technical advice to the building industry

(b) Housing studies — assistance to CMHC in their program of acceptance of materials and equipment and methods for construction under the National Housing Act

(c) Provision of services for the Associate Committees on the National Building Code and National Fire Code

(d) Regional services — stations at Halifax, Saskatoon, and Vancouver to provide advice to those concerned with building in these areas.

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MECHANICAL ENGINEERING

Division of Mechanical Engineering

Hydrodynamics

(a) Coastal engineering, river hydraulics, sedimentation, ice in rivers, wave studies

(b) Propeller and hull studies, steering and rough water characteristics

Thermodynamics

(a) Study of thermally ionized gases

(b) Aerodynamic studies of gas turbine components

(c) Boundary layer studies

VTOL Aircraft Propulsion Systems

(a) Optimization of turbo fan engine cycles for VTOL applications

(b) Interaction effects between intakes, nozzles, and environment

(c) Experimental studies of engine intakes

Fuels and Lubricants

(a) Low temperature gear lubricants

(b) Long term storage of hydrocarbon fuels

(c) Filtration of aviation fuels

(d) Steam turbine lubricants

(e) Solid lubricants

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MECHANICAL ENGINEERING

Railway Transportation

(a) Gas turbines for locomotive traction

(b) Air brake studies

(c) Effect of ice and snow on traffic control systems

(d) Freight car design

(e) Lubricating oils for diesel locomotives

Medical Instrumentation

(a) Vascular suturing instruments and techniques

(b) Instrumentation for neurosurgical procedures

Control Systems

(a) Optimization control of pyrometallurgical processes

(b) Human factors in engineering

(c) Biological control systems

Air Transportation

(a) Aircraft icing

(b) Study of bird collisions with aircraft

(c) Cold weather refuelling hazards

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NATIONAL AERONAUTICAL ESTABLISHMENT

National Aeronautical Establishment

Flight Research

(a) Airborne simulation of VTOL & STOL aircraft, using a specially converted helicopter

(b) Cooperation with Geological Survey on high resolution airborne magnetometry

(c) Studies of atmospheric turbulence

(d) Continuing development of Crash Position Indicator and accident data recorder

(e) Assessment of potentialities of air cushion vehicles in arctic areas

(f) Cooperative studies on the uses of aircraft in agriculture and forestry

Low Speed Aerodynamics

(a) Long-term research projects in aerodynamic design

(b) Assistance related to design and operational problems in the Canadian aircraft manufacturing and air transport industries

(c) Aerodynamic investigations of a non-aeronautical nature i.e., related to bridges, towers, ships superstructures, etc.

High Speed Aerodynamics

(a) Long-term studies of boundary layer flows and hypersonic flow

(b) Specific investigations for the aerospace industry, including extensive studies of rocket vehicle problems

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NATIONAL AERONAUTICAL ESTABLISHMENT

Unsteady Aerodynamics

(a) Development of free flight techniques to study models performing in simultaneous motion in several degrees of freedom

(b) Aerodynamics of sounding rockets

(c) Gas phase reaction kinetics

Structures and Materials

(a) Aircraft response and load statistics — program to record velocity, acceleration and altitude and load counts data for a number of Canadian built aircraft

(b) Structural analysis and optimization, with emphasis on airframes and rockets

(c) Research into the properties of materials used in the aerospace industries, and including evaluation of the oxidation resistance of superalloy coatings

(d) Studies of structural fatigue, and the development of techniques in fractographic analysis

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PRAIRIE REGIONAL LABORATORY

Prairie Regional Laboratory

Microbiology

Directed towards selecting specific strains of organisms and growing them to produce enzymes, antibiotics, amino acids, etc. Examples of projects are:

(a) Development and patenting of a system of continuous synchronous fermentation

(b) Development and patenting of a process for producing glyco-lipids

(c) Study of the mechanism of obligate parasitism in bacteria

(d) Isolation of cholesterol from a microorganism and study of its effects on temperature sensitivity and permeability of cell membranes

(e) Isolation and purification of enzyme systems involved in breakdown of carbohydrates and phenolic materials by microorganisms

(f) Studies on the production, structure and biosynthesis of microbial products, that have growth promoting or antibiotic activity

(g) Study of cell structure in relation to localization of functions

(h) Investigations of cell wall constituents and their break down by enzyme systems

(i) Breakdown of flavonoid materials by microflora in the rumen

(j) Studies on nitrogen fixation

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PRAIRIE REGIONAL LABORATORY

Plant Breeding and Nutrition

Directed to establishing relations between the chemical components of plants and genetic factors that can be controlled through plant breeding. Representative projects are listed below:

(a) Development of vapor phase analysis to permit studies in depth on fatty acids, terpenes, thioglucosides, carbohydrates, amino acids and phenolics

(b) Collaborative studies with plant breeders in C.D.A. and universities to develop rapeseed varieties that are low in erucic acid

(c) Collaborative studies with nutrionists on relations between the fatty acid composition of the diet and the depot fats of test animals

(d) Development of methods of analysis for thioglucosides and application of these methods to problems of plant breeding and nutrition

(e) Studies on the occurrence and biosynthesis of aromatic amino acids, flavonoids and phenolic compounds and their resistance to degradation by enzymes in micro-organisms

(f) The structure and nature of seed proteins in relation to nutritional problems

(g) Determination of terpenes in evergreens, and relations between composition and species

(h) Development of single cell cultures from wheat, soy bean, flax, potatoes and other crop plants. For use in the study of enzymatic synthesis

(i) Exploration of possibilities of producing new hybrids by using single cell cultures

(j) Study of effects of mutagens on single celled cultures

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PURE CHEMISTRY

Division of Pure Chemistry

Organic Studies

Bioorganic Chemistry

Chemistry of Transient Species

Natural Products and Organic Reactions

Organic Spectrochemistry

Organic Synthesis

Pyrroles and Porphyrins

Total Synthesis of Natural Products

X-ray Analysis

Physical Studies

Electron Spin Resonance

Mass Spectrometry

Molecular Spectroscopy

Nuclear Magnetic Resonance; Organic Crystal Semi-Conductors

Photochemistry and Radiation Chemistry

Physical Organic Chemistry

Thermodynamics at Low Temperatures; Imperfections in Solids

Thermodynamics of the Solid Gas Interface

Thermodynamics of Solutions

Theoretical Studies

Exciton Transport, Radiationless Transitions

Many-body Studies on Optical Properties of Solids

Quantum Chemistry

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PURE PHYSICS

Division of Pure Physics

Cosmic Rays and High Energy Particles

(a) Studies of charged particles in the Van Allen radiation belt, using satellites

(b) Studies of charged particles associated with auroral events, using sounding rockets

(c) A continuing study of long and short-term variations in the intensity of cosmic rays

(d) Study of high energy nuclear interactions induced by cosmic rays

Laser and Plasma Physics

(a) Experiments on the interaction of laser beams with plasmas

(b) Development of a ruby laser having a narrow spectral line-width, for use in scattering experiments

Solid State Physics

(a) Studies of the conduction electrons in metals and alloys

(b) Studies of the crystal chemistry and magnetic properties of alloys

Spectroscopy

A continuing study of the spectra and the structures of atoms and simple molecules. The laboratory contains the world's largest collection of high resolution spectrometers and spectrographs, and its accomplishments are universally recognized within the scientific community

Crystallography

X-ray diffraction studies of selected crystalline substances

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R A D I O & E L E C T R I C A L E N G I N E E R I N G

Radio and Electrical Engineering Division

Radio Astronomy

(a) Investigation of radio emissions of solar, planetary, galactic and extra-galactic origins

(b) Operation of National Radio Observatory, Algonquin Park

Upper Atmosphere Research

Studies of auroral phenomena, meteors, infrared emissions and airglow, using radar, photographic and visual techniques, together with rocket-borne instrumentation

Electron Physics

(a) Research in surface science, quantum electronics and gaseous electronics

(b) Development of ultrahigh vacuum instrumentation and techniques

Solid State

(a) Optical and electrical processes in organic and ionic crystals

(b) Theoretical studies of solid state devices

High Voltage

(a) Corona and interference tests on high voltage lines

(b) High voltage measurement techniques

Medical Electronics

Development of instrumentation used in diagnoses, treatment and research

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R A D I O & E L E C T R I C A L E N G I N E E R I N G

Navigational Aids

Development of navigational radar, beacons, position-fixing equipment

Precision Measurements and Standards

AC and DC current comparators, microwave calorimeters, impedance and attenuation standards

Instrumentation and Circuit Design

Telemetry systems development; low-noise receivers, electrical-mechanical-optical instrumentation for basic research projects

Computer Techniques

Data processing, man-machine communications, computer interfaces, information classification and retrieval, computer-aided teaching

Antenna Development

Basic studies in electromagnetics together with the provision of specialized services for the design of antennas and RF devices

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Space Research Facilities Branch

The thirty-five staff members of this branch direct the activities of more than two hundred contract workers in the operation of a rocket-launching facility at Fort Churchill, Manitoba, for the use of scientists in Canada and the U.S.A.

SPACE RESEARCH FACILITIES BRANCH

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TECHNICAL INFORMATION SERVICE

OF THE

NATIONAL RESEARCH COUNCIL OF CANADA

The N.R.C. Technical Information Service (T.I.S.) was established in 1945 to assist secondary manufacturing industry, small companies of less than 200 employees in particular, to keep abreast of new developments in technology and research. Of the 33,000 manufacturing companies in Canada, 96% employ 200 employees or less, representing 40% of the factory labour. They produce 40 % of the factory shipments. These figures correspond generally to those current in other industrial nations.

Small companies depend a great deal upon suppliers, competitors, trade associations, conferences and verbal contacts for technical information. They may subscribe to a few technical journals dealing with their own field but generally are not aware of technical information sources and channels.

Furthermore, technical and scientific literature holdings in public libraries across Canada, with few exceptions, are limited, and university libraries generally are not designed or suitable for industrial use.

Accordingly T.I.S., which consists of a group of professional engineers familiar with provincial industry and commerce, visits these small companies individually and, supported by a group of specialists in Ottawa having access to world-wide channels of information, provides them with a service which large companies have the resources, channels and experience to undertake for themselves.

The concept of T.I.S. originated personally with Mr. C.D. Howe and Dr. C.J. MacKenzie in 1945. Initially, it was established in the Research and Development Branch, Department of Reconstruction and Supply. One year later, at Mr. Howe's suggestion, it was transferred to N.R.C. because of better

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technical facilities and the information channels available. Paragraph 13(g) of the N.R.C. Act authorizes N.R.C. "to publish and sell or otherwise distribute such scientific and technical information as the Council deems necessary".

In 1952 the Provincial Research Councils or Foundations, by agreement, began taking over T.I.S. work in their provinces, for which they are paid an annual fee. (See Attachement 1.) These Councils are concerned with developing and exploiting the province's natural resources. Their field engineering services normally provide liaison between industry and the laboratories, and technical assistance with production. They are technically qualified to undertake T.I.S. work, thus avoiding duplication of travelling costs, waste of technical manpower, and confusion between federal and provincial services.

At first, to meet an obvious and pressing demand, T.I.S. concentrated on technical enquiry and answer activities. At the present time field officers from all field offices across Canada are visiting small companies periodically to discuss and help with their technical problems. In the Maritime and Western Provinces, where industry is less concentrated, many large companies are included. Large companies, of course, often request help directly.

Both field and Ottawa staff, with two or three exceptions, are graduate engineers with from 5 to 20 or more years of production experience. They are mostly mechanical or chemical engineers, to match the job. A statistical analysis of their background is shown in Attachment 2.

Field officers are key men in the information chain and deal personally with all levels of company personnel. In general they are the equivalent of sales engineers in industry.

The Ottawa staff officers generally are somewhat older, from 35 to 65. Personality is not so important except as related to their ability to get along with their colleagues and the field officers. Their industrial experience has been more varied and at a more senior level than the field officer. They

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must have a wide interest and curiosity in technology, judgment in assessing a query and the depth of answer required, ability to express themselves in writing to enquirers varying from technical laymen to chief engineers and senior scientists, and be capable of maintaining interest in a desk job in which the variety of technical content is intriguing but the output is a continuous flow of written replies every working day.

Their training is of the "on the job" contact type, concentrating mainly on locating and using information sources and dealing by correspondence with a wide variety of people in a wide variety of technical fields.

Staff officers are encouraged to attend scientific and industrial conferences in their fields at suitable intervals. Industrial engineers are sent on short, specialist courses to improve their capabilities and broaden their knowledge in specific areas.

The Head of T.I.S., with committments in several international organizations, travels abroad once or twice a year. Advantage of this is taken to visit other information services to exchange experiences, techniques and procedures, and to compare results. Section heads make occasional foreign trips to compare and improve their own operations.

An annual conference of field officers has been held for many years, rotating in location between field offices. Informal interchange of experiences and unilateral cooperation between field offices upgrades their operating effectiveness.

An understanding of the needs of small industry cannot be reached by simple scaling down of the experience and requirements of large companies. A technical information service designed for small companies will not entirely meet the needs of large companies and vice versa, and coverage of both sectors involves compromises.

The small industrialist generally will not take time to write to N.R.C.

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or other government laboratories about his technical problems, partly because he may feel his problems are at too low a level for N.R.C. consideration, and partly because he may lack the technical ability to assess and describe his problem. He welcomes the visit of a personable and knowledgeable engineer, sometimes just as an outlet for his gripes against the government, business conditions, competitors, etc. Eventually he will mention technical problems which he knows exists in his operations, or a trip through his plant reveals others of which he is unaware.

Any queries unanswerable locally are referred to T.I.S. in Ottawa. Queries are also received directly from companies who have become aware of T.I.S., or by referral from other government departments. Attachment 3 indicates the origin of the enquiries.

The Ottawa staff has numerous and wide-ranging sources and channels of information available:- firstly, their own personal knowledge and experience and that of their colleagues; secondly, over 75,000 previous enquiries and answers; thirdly, the National Science Library and its associated library networks; fourthly, numerous scientists and engineers in government research laboratories and operating divisions; fifthly, large companies and industrial associations; and, finally, technical information centres, government and commercial organizations in foreign countries.

Technical information provided by T.I.S. differs from that given by the National Science Library. The two organizations work closely together and cross refer enquiries as needed.

By agreement, T.I.S. refers all queries in their particular fields to the Forest Products Laboratories and the N.R.C. Division of Building Research.

Canada is the second country in the world, after the Netherlands, to use the field officer approach to manufacturing industry, and a number of countries since have followed suit. The association of T.I.S. with a scientific

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institution rather than a government department has been most advantageous. Small companies seem to distrust the motives of government departments. However, a scientific organization such as a research council, although it is a government agency, is regarded as a neutral organization, objective in nature, and with which discussion can be open. Other countries report the same attitude.

Aside from assisting with technical problems, field officers provide a cross-fertilization of ideas, techniques and procedures between companies, subject always to the maintenance of commercial security. They sometimes put companies in contact with each other to build up local sources of supply and profitable business cooperation, or even mergers. They also help on small-town problems concerning community development, tourist trade, establishment of cooperatives and other items of a nontechnical nature.

However, although the Question and Answer Service performs a most useful function, much of its output necessarily is passive in nature. It generally supplies only information that is asked for by industry, including only such new technology as is related to the enquiry. In 1960, Dr. Steacie, then President of N.R.C., directed that T.I.S. should broaden its activities to meet its responsibilities in a more positive manner.

The first step was a planned expansion of staff on a 5 year basis (See Attachment 2(c)).

The T.I.S. operating budget, which does not include salaries and other administrative and overhead costs absorbed by the general N.R.C. budget, has increased from $20,000 to $45,000 per year. The provincial fees have increased from a total of $62,000 to $387,000, which covers salaries and some administrative overhead. Each province receives approximately the same sum, averaging $64,500. This is an unbalance in favour of the Western and Maritime provinces which, however, are less favoured as to availability of information.

The second step was the organization of the Industrial Engineering

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Section in 1962. Since our Technical Enquiry officers had only general knowledge and experience in this area, professional engineers specializing in such work were employed and now number 15 in the field and 1 in Ottawa. A description of their work area is given in Attachement 4 and their distribution of effort in Attachements 5 and 6. To meet this need, the Industrial Engineering Section informs small companies of IE techniques and assists them in their application, on a do-it-yourself basis. It encourages companies to hire trained staff or send their own staff on training courses and promotes the establishment of suitable training facilities by educational authorities.

The third step in expanding T.I.S. activities was the formation of the Technological Developments Section in 1964 to provide selected information covering all areas of industrial technology and research.

This is done by mail directly from Ottawa in the form of Checklists of technical articles selected from the world's scientific and technical literature, Technical Reviews of technological processes, and Technical Films provided to the National Film Library for loan to industry.

Over 30,000 manufacturing companies have been asked to submit a "profile of interest", a listing of the product fields of interest to their company; 3,000 have replied and their profiles have been registered in a computer.

All answers to technical enquiries and all items selected by the Technological Developments group and IE Section are put into the computer. Periodically the profiles of particular companies in a particular field of industry are matched by the computer to these items. The items selected by the computer are sent directly to the companies as a checklist.

Items are selected not only from the literature directly related to a company's interest, but from literature covering associated production fields and scientific disciplines. For example, an electronic device developed for a control in the machine tool industry may be recognized by T.I.S. as having an application in the chemical industry, which may be unaware of its existence.

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Technical Review are summaries of "state of the art" written for technical laymen on developments that generate a number of similar enquiries due to publicity on their industrial potential, such as "thermoelectricity", "spark erosion machining", etc.

A film collection has been started which is handled on behalf of T.I.S. by the National Science Film Library for loan to industry at nominal charges, control of the distribution being maintained by T.I.S. to ensure that first priority is given to industry. These films cover industrial engineering techniques and new or current industrial processes, and are chosen to illustrate their nature and potential application to industrial processes.

If a program of foreign aid were launched under the auspices of the External Aid office and T.I.S., it is thought that a most useful contribution to the development of industry in developing countries could be made at relatively low cost. Aside from the social and political effects of such aid, it could also lead to a development of trade between Canada and these countries.

In considering the future development of T.I.S. in the next five years it is felt that the existing activities of T.I.S. are meeting definite industrial needs, in fields more than large enough to occupy a service many times the size of our present organization. Advances in mechanical retrieval and transmission of information will assist our service, but will give us a greater mass of material to read, select and disseminate, involving more manpower.

The manpower factor also is involved in the amount of publicity given to T.I.S. activities. Criticism is sometimes directed at TIS that the service is not well known or sufficiently publicized. This is true to some extent but there are two major reasons for it. One is that companies do not need to use the service daily. Changes of personnel occur frequently in industry

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and we often find, when a company executive indicates he has never heard of TIS, that we have helped his company many times over a period of several years.

Furthermore, TIS always has a backlog of work and must be careful to preserve a balance between the number of field officers, who are the salesmen, and the Ottawa staff who are the producers. It is definitely harmful to publicize a service which cannot meet the demand created by publicity. Unlike a business, which can expand as advertising increases the demand for its product, TIS expansion is related to a more or less fixed rate of growth, governed by its share of NRC's budget and manpower allocation.

It is felt, therefore, that the major hindrance to the effective performance of TIS functions will continue to be the lack of manpower and budget to meet both the existing and potential requirements for technical information.

Small industry is becoming more sophisticated, a trend which is noticeable in the queries received in recent years. Accordingly, upgrading of the level of staff competence by courses and other means will be of increasing importance, and will involve a number of problems.

The Province of Quebec presents some special problems. Bilingual engineers are most difficult to obtain, being few in number and greatly in demand by industry. Percentages of TISstaff operationally effective in both languages are given in Attachment 2 (c)(vi). Unless the technical literature from France becomes more acceptable, or French Canadian literature increases, or the small companies become more bilingual, this problem will continue to exist.

From time to time the provision of information free of charge is queried, frequently based on the old cliché that the only information industry holds in high regard is that which has to be paid for. However, the small industrialist generally is not prepared to pay for something, the effectiveness of which he cannot assess or evaluate in advance - particularly if it is software rather than a product or a process. If it is costly by his standards

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he will get along without it, regardless of its potential value.

If TIS were obliged to charge for its services, it would either die or its efforts would be chained to a small circle of clientele whose needs could be served by a commercial organization, if one could be found. Nevertheless, some aspects of the work of the Technological Developments Section may prove suitable for the development of a subscription service and this will be borne in mind.

The possibility of extending TIS operations to meet the needs of large companies has been a continuing consideration for several years. The field service type of operation is not considered suitable for large companies, due to the size, complexity and sophisticated nature of their organization and technical information needs. The Technical Enquiry and Industrial Engineering Sections can be of some direct assistance but it is in the Technological Developments Section that the greatest potential exists. Even here, the basic differences between large and small companies present problems but our future development will attempt to meet the needs of both sectors of industry.

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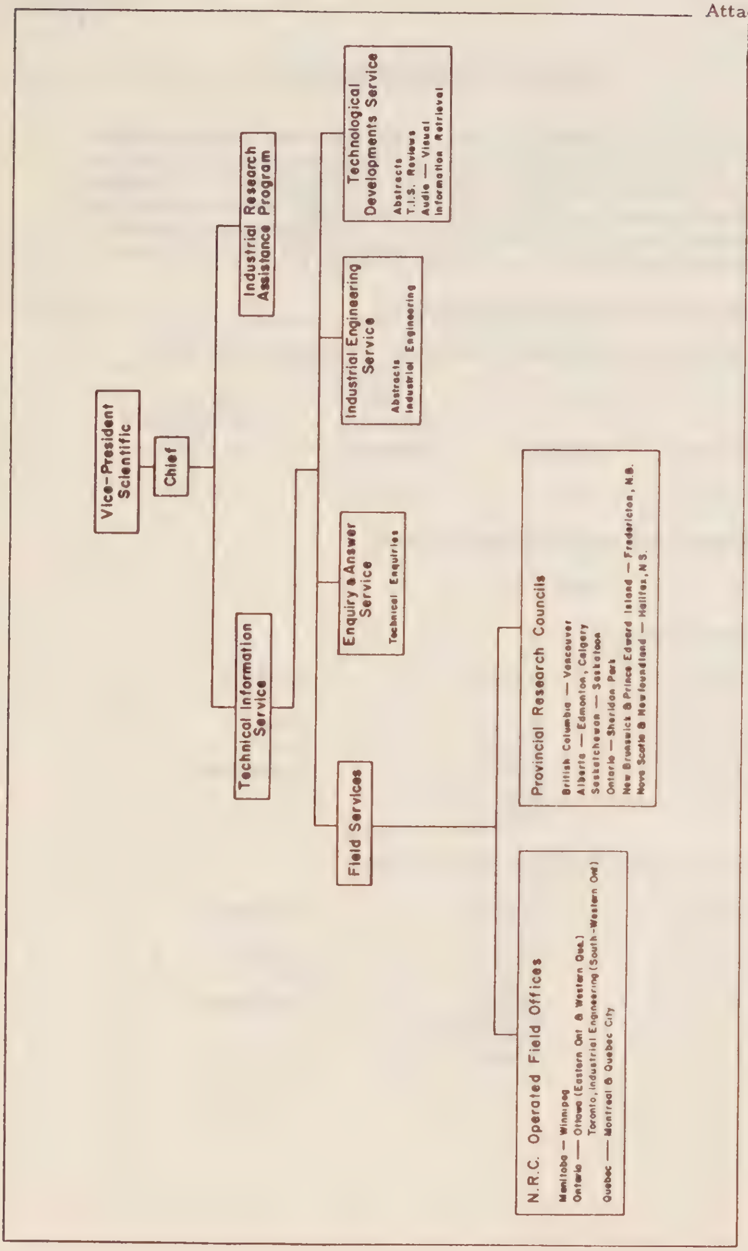
Attachment 1



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TECHNICAL INFORMATION SERVICE

Note:-
T. I. S. provides the administrative staff, 3 professional and 2 clerical, and the operating costs of the Industrial Research Assistance Program, the operations of which are described elsewhere. IRAP staff are qualified for T. I. S. work and are included in the summary below as T. I. S. personnel. Total funds show the total operating costs of T. I. S. and IRAP but do not include the IRAP grants. Under operating funds, the division between IRAP and T. I. S. costs is shown.

2. 5) Personnel associated with scientific activities

a) Current personnel establishment and people on strength (in brackets).

Professional	Technical	Clerical & Regulatory	Secretarial, Stenographic, Typing
32 (32)	1 (1)	6 (6)	12 (12)

b) Professional staff on administrative duties -

TIS 2 IRAP 3

c) i) Country of birth

Bachelor		Master		Doctorate	
Canada	15	Canada	5	Canada	2
U.K.	2	Poland	1	U.K.	1
U.S.A.	1	China	1	Switzerland	1
B. W. I.	1	Netherlands	1		
		France	1		

c) ii) Country in which secondary education taken.

Bachelor		Master		Doctorate	
Canada	16	Canada	5	Canada	2
U.K.	2	U.K.	1	U.K.	1
U.S.A.	1	Poland	1	Switzerland	1
		Netherlands	1		
		France	1		

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c) iii) Country in which university degree taken.

Bachelor		Master		Doctorate	
Canada	15	Canada	3	Canada	1
U.K.	2	U.S.A.	3	U.K.	1
U.S.A.	2	Poland	1	U.S.A.	1
		Netherlands	1	Switzerland	1
		France	1		

c) iv) Working years since graduation and in present organization.

Number of Years	Working Since Graduation			With N.R.C.		
	B.	M.	D.	B.	M.	D.
0 - 2				4	4	
2				2		2
3				3		
4	1			1	3	
5				2		
6					1	1
7		1				
8				2	1	
9				1		
10						
11						
12						
13						
14	1		1			
15	2					
16	1	1				
17						
18				1		
19	3					
20		1				
21				3		
22		1				
23						
24			1			
25			1			1
26	2					
27	2					
28						
29	2	1				
30	1					
31		1	1			
32		1				

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2. 5) Personnel associated with scientific activities

c) iv) (CONT'D)

Number of Years	Working Since Graduation			With N.R.C.		
	B.	M.	D.	B.	M.	D.
33						
34						
35	1	1				
36						
37						
38	1					
39	1	1				
40						
41	1					

c) v) Average age

Bachelor	Master	Doctorate
50	50.8	50.5

c) vi) Percentage operationally effective in English and French.

Bachelor	Master	Doctorate
36.8%	33.3%	25%

d) Total professional staff in each degree category.

	Bachelor	Master	Doctorate
1962	10	2	1
1963	11	5	2
1964	13	6	2
1965	14	7	2
1966	19	6	3
1967	18	6	4
1968	19	9	4
1969	22 (25)	8	4
1970	26	9	5
1971	29	10	6
1972	31	10	6
1973	33	10	7

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e) Turnover of professional staff.

	Retired			Resigned			Hired		
	B.	M.	D.	B.	M.	D.	B.	M.	D.
1962				1			3	2	1
1963				2			3	2	
1964							1	1	
1965				1	1		5		1
1966				1			1		1
1967		1		3			2	4	

f) Percentage employed by industry, universities, provinces and federal govt.

	Bachelor	Master	Doctorate
(i) Industry	95%	100%	75%
(ii) Universities	5%	33%	50%
(iii) Provinces	10%		
(iv) Federal	20%	10%	

g) Number on educational leave - none

h) University summer students - 8

2. 6) Expenditures associated with scientific activities

a) Total Funds

Functions: (3) scientific information

Scientific discipline: (1) engineering and technology
(5) support of R&D in industry

Areas of application: (9) industry

Funds	
1962-63	$ 346,500.
1963-64	450,000.
1964-65	510,500.
1965-66	598,273.
1966-67	733,766.
1967-68	844,000.
1968-69	940,000.

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2. 6) Expenditures associated with scientific activities

b) Operating and capital funds.

Operating Funds

	I. R. A.	T. I. S.
1962-63	$ 16,500.	$ 330,000.
1963-64	20,000.	430,000.
1964-65	25,000.	485,500.
1965-66	25,000.	573,273.
1966-67	33,000.	700,766.
1967-68	50,000.	794,000.
1968-69	50,000.	890,000.

Capital Funds

1965-66	$ 10,000.

c) Funds to further professional university education - NIL

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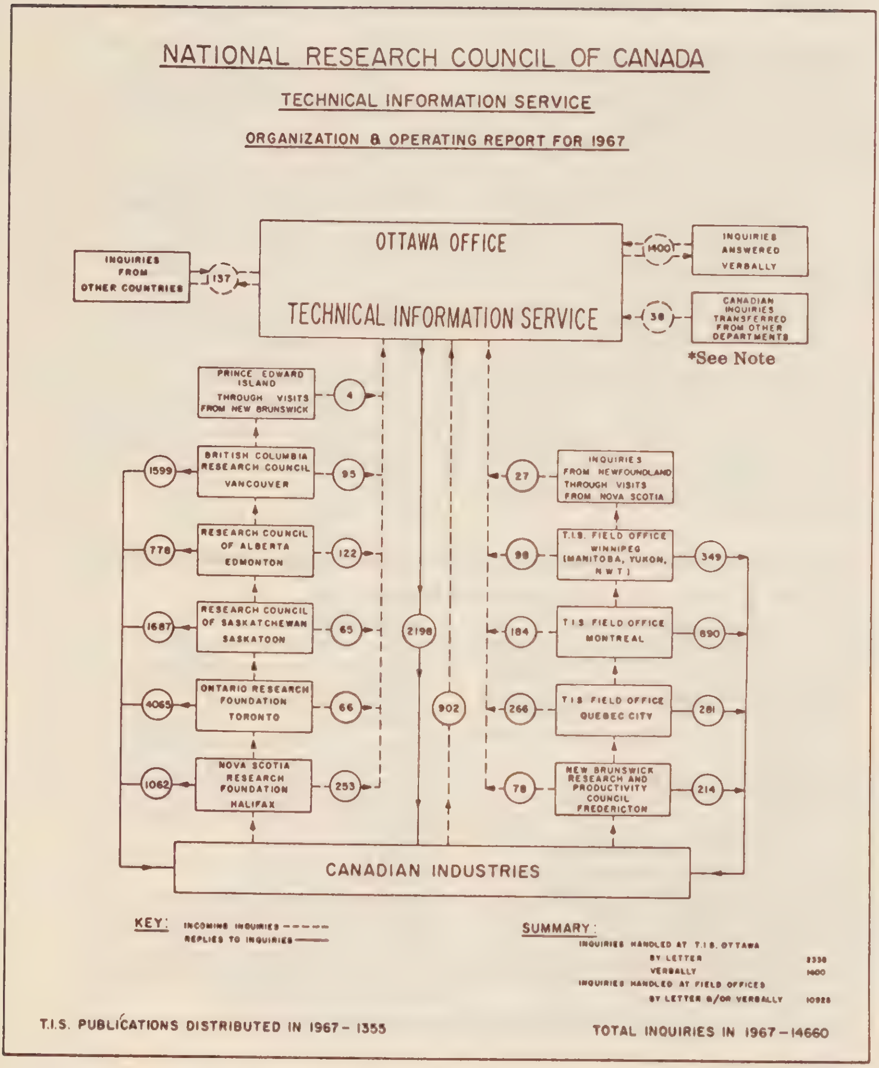
Attachment 3



* Note: 215 enquiries transferred to other government departments

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Attachment 4

Now . . . industrial engineers are moving up

THE TRADITIONAL VIEW of an industrial engineer is fast becoming obsolete. Just a short time ago, the term "industrial engineer" was considered just another way of saying "time study man". The terms were virtually interchangeable.

But now the industrial engineer is starting to come into his own. With only one Canadian university (University of Toronto) offering a course in industrial engineering, the field is making rapid progress despite lack of university-level recognition.

The big change is that industrial engineers are breaking the organizational ties that have bound them to the production side of the business. Management is recognizing that their special skills and talents can be applied on a broad scale to all parts of the organization. So industrial engineering is becoming recognized as a staff function covering virtually every area in the organization.

Some of the larger companies are still bucking this trend by establishing multiple staffs of specialists; one for production, one for office systems and procedures, and even separate groups devoted to operations research. The tools and techniques they use are virtually identical, and this form of organization creates duplication and minimizes the effectiveness of each of the groups. The very presence of organizational lines inhibits the effective use of their talents.

That is where smaller companies are finding the big benefit. By moving the industrial engineer up to a staff position reporting to the general manager (or equivalent) a single department is free to coordinate efforts in every phase of the company's activities.

Take a look at the box below. This is a listing of the areas of experience being proposed by the American Institute of Industrial Engineers to evaluate membership qualifications. You can recognize a number of areas that are currently trying to establish themselves as separate specialties. Yet each of them requires a broad general knowledge of many of the other areas and techniques listed.

It would be a criminal waste to reduce the effectiveness of any of the powerful new techniques currently being developed and applied through failure to recognize the interdependence of them. This can only be avoided by centralizing responsibility for these vital management techniques.

The industrial engineering department is the logical place for this centralization. It contains most of the needed skills now. Restricting the application of these skills by setting up artificial organizational barriers can only result in weakening the entire organization.

Don't let it happen in your plant.

Here's a new look at what Industrial Engineers do:

Industrial Engineering experience . . . shall consist of experience in research, design, development, and installation of plans, methods, systems, and controls involved in the following recognized Industrial Engineering activities as applied to any function in any enterprise:

1. Selection of processes and assembling methods.
2. Selection of tools and equipment.
3. Design of facilities, including layout of buildings, machines, and equipment, materials handling equipment; raw materials and product storage facilities.
4. Design and/or improvement of planning and control systems for: Distribution of goods and services, production, inventory, quality, plant maintenance and engineering, or any other function.
5. Development of cost control systems such as budgetary controls, cost analysis, and standard cost systems.
6. Product development.
7. Develop and install wage incentive systems.
8. Development of performance measures and standards (including work measurement and evaluation systems).
9. Job evaluation.
10. Evaluation of reliability and performances.
11. Operations research, including such items as mathematical analysis, systems simulation, linear programming, and decision theory.
12. Design and installation of data processing systems.
13. Office systems, procedures and policies.
14. Organizational planning.
15. Plant location surveys which consider potential market for plant, raw material sources, labor supply, financing, and taxes.

(Proposed categories of experience to determine membership qualifications in American Institute of Industrial Engineers.)

Appendix H
Attachment 5

National Research Council of Canada - Technical Information Service

Industrial Engineering Section

Summary of Companies Assisted Within Noted Manufacturing Groups

June 1967 - May 1968

	Group	All Canada	N.S./Nfld.	N.B./P.E.I.	Que.	Ont.	Man.	Sask.	Alta.	B.C.
1.	Food	42	1	7	4	7	-	2	9	12
2.	Tobacco	-	-	-	-	-	-	-	-	-
3.	Rubber	5	-	-	1	1	-	2	-	1
4.	Leather	8	1	-	4	2	-	-	-	-
5.	Textile	8	-	-	5	-	-	1	1	1
6.	Knitting	1	1	-	-	-	-	-	-	-
7.	Clothing	14	2	1	7	2	-	-	2	1
8.	Wood	35	5	2	4	4	-	1	6	14
9.	Furniture	16	2	-	6	-	-	1	2	6
10.	Paper	9	1	1	4	4	-	-	-	-
11.	Printing	14	1	-	-	3	-	6	1	3
12.	Primary Metal	8	-	1	3	2	-	1	-	1
13.	Metal Fab.	65	1	8	15	17	-	5	3	17
14.	Machinery	21	-	1	6	4	-	4	1	6
15.	Transportation	22	3	1	8	1	-	1	4	5
16.	Electrical	19	1	-	11	5	-	2	1	-
17.	Non-Metallic	17	-	1	9	3	-	-	4	-
18.	Petroleum	-	-	-	-	-	-	-	-	-
19.	Chemical	19	-	-	8	2	-	-	7	4
20.	Miscellaneous	30	-	1	8	7	-	2	6	7
21.	Other than Manufacturing	109	1	8	9	14	-	24	22	21
	Total	462	20	32	112	78	0	52	69	99

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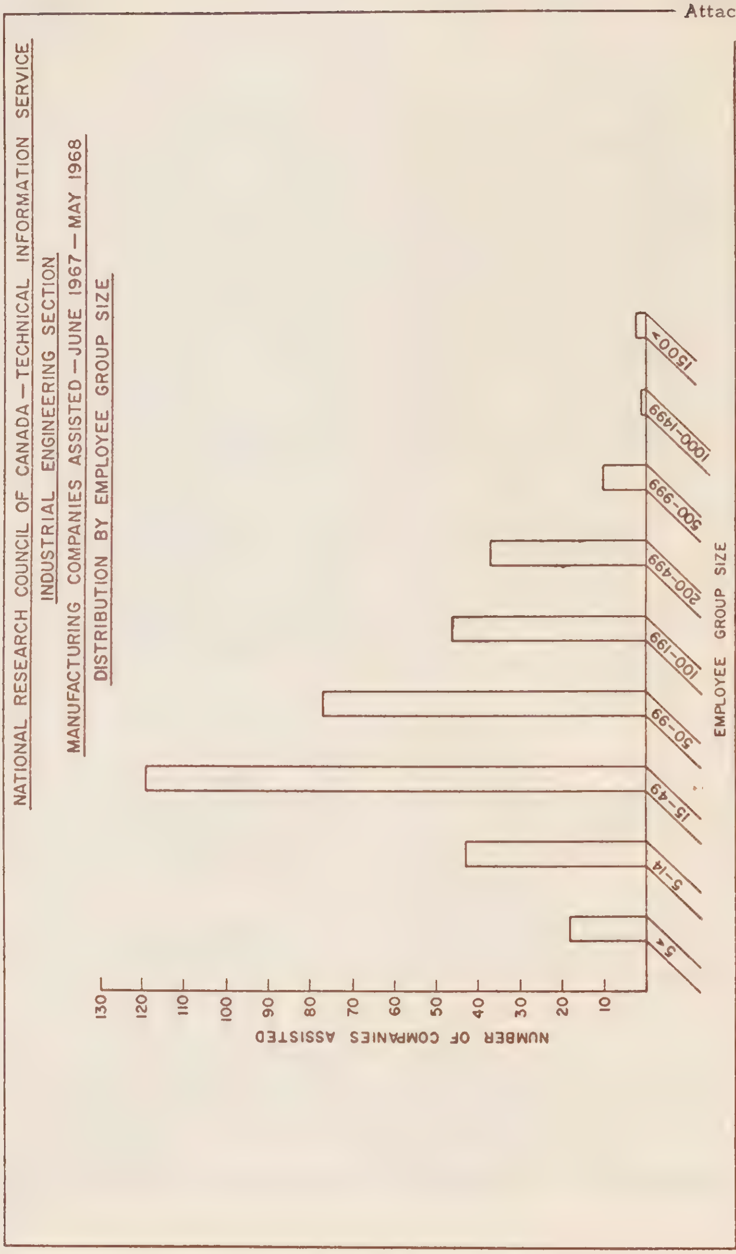
Attachment 6



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INTERNATIONAL EXCHANGES

(a) Formal agreements with organizations outside Canada.

(i) Since 1959, the National Research Council has had an agreement with the Soviet Academy of Sciences providing for the exchange of (a) three senior scientists and (b) seven research workers each year. A copy of the current agreement is attached (Attachment 1). Also attached is a list of Canadian scientists who have visited the U.S.S.R. under the agreement (Attachment 2).

(ii) Under the Cultural Agreement between the Government of Canada and the Government of France, the National Research Council has accepted responsibilities for a programme of exchanges of scientists with France. A copy of the agreement is attached (Attachment 3). Also attached is a list of Canadian scientists who have visited France under the agreement (Attachment 4).

(iii) Under the agreement between the Government of Canada and the Government of Brazil, signed August, 1968, the National Research Council has agreed to a programme of scientific exchanges with the Conselho Nacional de Pesquisas of Brazil. A copy of the agreement is attached (Attachment 4).

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(b) International representation and the monitoring of Scientific Activities Outside of Canada.

The National Research Council is the adhering body for Canada for a number of international scientific unions and non-governmental organizations (see attached list) and takes responsibility for Canadian representation at meetings of these organizations acting on the recommendations of national committees established to advise Council on Canadian participation.

The National Research Council makes use of all traditional methods of monitoring scientific activities outside of Canada. Through the National Science Library the N. R. C. takes responsibility to ensure that there is in Canada access to all published scientific and technical reports. The N. R. C. provides support for Canadian scientists to attend scientific conferences and symposia taking place outside Canada and also supports symposia in Canada at which foreign scientists are invited to present scientific papers. The N. R. C. also receives through scientific liaison offices abroad reports on the scientific activities of foreign governments and on developments in the organization and financing of research. Finally, representation at various international organizations such as O. E. C. D. and Unesco provides an opportunity to observe and to compare scientific developments in countries outside Canada.

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(c) Overseas Offices:

From 1945 until early this year the National Research Council operated Scientific Liaison Offices abroad as part of its responsibility for the promotion of science in Canada. N. R. C. officers abroad have had responsibility for scientific liaison on behalf not only of the National Research Council, but of all scientific organizations in Canada who might have use for their services. The N. R. C. officers were accredited to the respective Canadian Missions as Scientific Attaches and had responsibility to advise the Head of Missions on Scientific matters and to undertake scientific activities on his behalf.

In August 1967 the decision was taken that N. R. C. should no longer have responsibility for Scientific Attaches at Embassies abroad. At the time of this decision N. R. C. had officers at four missions: Washington, London, Paris and O. E. C. D. (Paris).

Although N. R. C. ceased to have responsibility for Scientific Attaches, an N. R. C. Liaison Office has been maintained in London in order to carry out technical liaison on behalf of the scientific and engineering divisions of N. R. C.

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National Research Council of Canada

O T T A W A

Leningrad,
April 28, 1966

Academician M.V. Keldysh,
President of the Academy of
Sciences of the U.S.S.R.,
Moscow.

On the exchange of scientists between the National Research Council of Canada and the U.S.S.R. Academy of Sciences.

Dear Academician Keldysh,

I have the honour to inform you that the National Research Council of Canada accepts the following proposals on the continuation of the programme of scientific exchanges between the National Research Council of Canada and the U.S.S.R. Academy of Sciences. I agree that scientific exchanges during two years starting September 1, 1966 be implemented in conformity with the principles stated below and that the present Agreement be re-examined at the end of the two-year period at the wish of one of the two contracting Parties or be prolonged by mutual consent of both Parties.

1. The National Research Council of Canada and the U.S.S.R. Academy of Sciences during these two years will exchange scientists as follows:

a) Six eminent scientists from each side for a period in each case up to one month to give lectures, conduct seminars and to become familiar with research and scientific institutions engaged in research in various problems of science. The sending side will propose the names of lecturers and subjects of lectures; if acceptable the receiving side will make all necessary arrangements for the visit.

b) Fourteen research workers from each side for periods up

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to nine months for the purpose of conducting research or of acquainting the visiting scientist with current research in his field in the receiving country. The field of specialisation in which the scientist intends to work will be agreed between the two sides in each separate case.

2. The Parties agree to encourage and assist in implementing mutually acceptable visits of scientific workers, organised by scientific institutions of both countries, over and above the visits under item 1. The details of such visits, including the choice of fields of specialisation, duration of visits and financial conditions, will be negotiated directly by the National Research Council of Canada and the U.S.S.R. Academy of Sciences.

3. Nominations for visits in accordance with item 1 will be submitted by the sending side for the consideration of the receiving side not later than four months before the proposed date of arrival in the host country. In each case the sending side will accompany the nomination with the essential details of the nominated scientist: field of specialisation, short biography, list of scientific publications, outline programme of scientific work (including scientific centres and institutions which it is wished to visit and specific scientists with whom meetings are desired), knowledge of foreign languages and subjects of lectures which he might make during his stay in the host country.

The receiving side undertakes to reply to each request within three months of receiving it. In accepting a visit, the receiving side may make suggestions for changes in time or duration of the visit and in the list of institutions to be visited. Having received consent, the sending side, not later than 10 days in advance, will advise the receiving side of the date of arrival of the scientist.

4. Financial arrangements for the exchanges under item 1 shall be as follows:

a) The sending side will meet the travel expenses of the scientist to and from the main arrival point, which normally will be Ottawa or Moscow.

b) The receiving side will provide living accommodation and medical services as well as meet the travel expenses within the country when such travel is connected with the object of the visit. All the expenses connected with the scientific

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work of the visiting scientist will be defrayed by the receiving side.

c) In addition to covering the expenses stipulated in 4b above, the receiving side will pay a basic allowance to the visiting scientist according to the following per diem rates:

Category I	(Eminent scientists as specified in item 1a):	$12.00 Canadian 10.00 Roubles
Category II	(Research workers as specified in item 1b):	$ 9.00 Canadian 7.50 Roubles

Any additional allowances which may be required shall be paid by the sending side.

5. Visas shall be procured through normal channels. Both sides will take steps to facilitate the obtaining of the visas by exchange scientists to enable them to arrive in the receiving country at the agreed time. All correspondence connected with the implementation of scientific exchanges will be conducted directly between the National Research Council of Canada and the U.S.S.R. Academy of Sciences.

Yours sincerely,

K.F. Tupper,
Vice-President (Scientific),
National Research Council of Canada.

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CANADIAN SCIENTISTS WHO HAVE VISITED THE USSR UNDER THE NATIONAL RESEARCH COUNCIL AGREEMENT

NAME	AFFILIATION	DISCIPLINE	YEAR
Dr. J.W. Boyes	McGill University	Genetics	1960
Prof J.M. Ham	University of Toronto	Electrical Eng.	1960
Prof H.R. Rice	University of Toronto	Mining Engineering	1960
Dr. W.B. Pearson	National Research Council	Physics	1960
Prof L.H.J. Shebeski	University of Manitoba	Plant Science	1960
Dr. C.A. Winkler	McGill University	Chemistry	1960/61
Dr. J.G. Foulks	University of British Columbia	Pharmacology	1960/61
Dr. R.T. Coupland	University of Saskatchewan	Plant Ecology	1961
Dr. J.C. Ritchie	University of Manitoba	Botany	1961
Dr. B. Conway	University of Ottawa	Chemistry	1961
Dr. G.J. Odgers	Dominion Observatory - Victoria	Astronomy	1961
Dr. W.E. Sackston	Department of Agriculture	Plant Pathology	1961
Dr. J.E. Gill	McGill University	Geology	1961
Dr. B.D. Burns	McGill University	Physiology	1961
Dr. I.I. Glass	University of Toronto	Aeronautical Eng.	1961
Dr. G.F. Wright	University of Toronto	Chemistry	1961/62
Dr. C.S. Beals	Dominion Observatory	Astronomy	1962
Dr. W.R. Boyle	Department of Mines & Technical Surveys	Geochemistry	1962
Dr. P.A. Hacquebard	Department of Mines & Technical Surveys	Palaeontology	1962
Dr. J.D. Keys	Department of Mines & Technical Surveys	Physics	1963
Dr. F.R. Lipsett	National Research Council	Physics	1963
Dr. W.G. Henry	National Research Council	Physics	1963
Dr. J.M. Cameron	Department of Forestry	Pathology	1963
Dr. R.U. Lemieux	University of Alberta - Edmonton	Chemistry	1963
Dr. R.W. Stewart	University of British Columbia	Oceanography	1963
Dr. J.L. Bolton	Department of Agriculture	Forage Crops	1963
Dr. K. Winterton	Department of Mines & Technical Surveys	Physical Metallurgy	1963
Dr. J.V. Basmajian	Queen's University	Anatomy	1963
Dr. L.J. Kamin	McMaster University	Psychology	1963
Dr. H.E. Welch	Department of Agriculture	Biology	1963
Dr. F.L.M. Pattison	University of Western Ontario	Chemistry	1963

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NAME	AFFILIATION	DISCIPLINE	YEAR
Dr. K. Ronald	Fisheries Research Board	Parasitology	1963
Dr. L.G. Berry	Queen's University	Geology	1964
Dr. P.A. Kondra	University of Manitoba	Poultry Science	1964
Dr. S.G. Mason	Pulp & Paper Research Institute	Physical Chemistry	1964
Dr. H. Reeves	University of Montreal	Physics	1965
Dr. R.E. Bell	McGill University	Physics	1965
Dr. S.K. Brownstein	National Research Council	Chemistry	1965
Dr. G.G.E. Scudder	University of British Columbia	Zoology	1965
Dr. W.W. Moorhouse	University of Toronto	Geology	1965
Dr. P.C. Trussell	British Columbia Research Council	Applied Biology	1965
Dr. J.W.T. Spinks	University of Saskatchewan - Saskatoon	Chemistry	1965
Dr. W.A. Alexander	National Research Council	Chemistry	1965/66
Dr. B.K. Bhattacharyya	Department of Mines and Technical Surveys	Earth Sciences	1965/66
Dr. G.A. Gross	Department of Mines and Technical Surveys	Geology	1966
Dr. D.H. Hall	University of Manitoba	Geophysics	1966
Dr. I. Halperin	Queen's University	Mathematics	1966
Dr. G.M. Weaver	Department of Agriculture	Plant Breeding	1966
Dr. J.K.N. Jones	Queen's University	Chemistry	1966
Dr. L.A. Lorch	University of Alberta - Edmonton	Mathematics	1966/67
Dr. S. Pond	University of British Columbia	Oceanography	1966/67
Dr. W.M. Tupper	National Research Council	Geology	1967
Dr. J.R. Colvin	National Research Council	Biosciences	1967
Dr. P.K. Anderson	University of Calgary	Biology	1967
Dr. W.D. Finn	University of British Columbia	Civil Engineering	1967
Dr. A.D. Booth	University of Saskatchewan	Engineering	1967
Dr. R.G. Albright	University of Toronto	Chemistry	1967/68
Dr. C.M. Woodside	National Research Council	Mechanical Engineering	1967/68
Dr. M.J. Freeman	University of British Columbia	Physics	1967/68
Dr. R.J. Rossiter	University of Western Ontario	Biochemistry	1968
Dr. R.E. Beschel	Queen's University	Geobotony	1968
Dr. F.L. Curzon	University of British Columbia	Physics	1968
Dr. J.R. Prescott	University of Calgary	Physics	1968
Dr. J. Genest	Clinical Research Institute - Montreal	Pathology	1968

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NAME	AFFILIATION	DISCIPLINE	YEAR
Dr. W.O. Pruitt	Memorial University Newfoundland	Ecology	1968
Dr. M. Weintraub	Department of Agriculture - Vancouver	Plant Virology	1968
Dr. G.B. Craig	University of Toronto	Metallurgy	1968
Dr. R.J.W. Douglas	Department of Energy Mines and Resources	Geology	1968

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Paris,

January 27, 1967.

SCIENTIFIC EXCHANGES: PROGRAMME ACCEPTED IN DISCUSSIONS BETWEEN THE NATIONAL RESEARCH COUNCIL DELEGATION AND THE DIRECTION GENERALE DES AFFAIRES CULTURELLES ET TECHNIQUES DU MINISTERE DES AFFAIRES ETRANGERES

The Joint Committee has noted the results of the work carried out during the stay in France in January, 1967 of a Canadian Scientific Delegation which, in accordance with the decision mentioned in point IV (5) of the Minutes of the Franco-Canadian Cultural Conversations of September 29, 1967, went to Paris for detailed discussion of the program of scientific exchanges between the two countries.

The Joint Committee approves the program adopted during this visit and resolves to include it hereinafter in the minutes of the present meeting.

PROGRAM OF SCIENTIFIC EXCHANGES FOR 1967

The exchanges pertain to the following scientific disciplines: exact and natural sciences (mathematics, astronomy, geophysics, earth sciences, physics, chemistry, biology, oceanography, etc.).

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Complete freedom is afforded to each country regarding the nature of the disciplines chosen by the exchange specialists.

I - EXCHANGES OF INDIVIDUALS

A) - The exchanges will involve first of all eminent scientists, if possible as many as ten a year, who will carry out missions lasting two to four weeks. The National Research Council of Canada, on the one hand, and LA DIRECTION GENERALE DES RELATIONS CULTURELLES, on the other, will be responsible for the travel and living expenses of their respective nationals.

B) - The exchanges will also involve research workers, if possible as many as eight a year, who already have a certain amount of experience in research, and are capable of executing programs of several months up to one year, with a view to pursuing research programs in the universities or scientific institutes of the other contracting party. The travel expenses of the research worker and his salary shall be the responsibility of the country of origin.

II - EXCHANGES OF SCIENTIFIC INFORMATION

The exchange of scientific information at the present time is based on the agreements concluded between the National Science Library of Canada on the one hand, and the CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE and L'ACADEMIE

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DES SCIENCES, on the other.

It is understood that the National Science Library of Canada and LE CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE are jointly considering what additional arrangements might facilitate an increase in the exchanges.

III - COLLOQUIA

A) - One or two colloquia will be organized each year in one or the other of the two countries. They will be followed by visits to laboratories and scientific institutes. The number of these colloquia and the choice of subjects will be determined on the basis of advice from the French and Canadian scientific authorities.

The travelling expenses of the members of each delegation will be the responsibility of their country of origin.

B) - The two countries are promoting the invitation of a certain number of scientists and research workers, as many as ten from each side, on the occasion of scientific meetings organized in their respective territories. The travelling and living expenses are the responsibility of the host country.

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IV - CO-OPERATIVE RESEARCH

On approval of the French and Canadian scientific authorities, especially when colloquia are being held, the possibility and usefulness of a co-operative research in a given subject may be examined.

V - DURATION

The 1967 program will be repeated in 1968.

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EXCHANGE AGREEMENT WITH FRANCE

VISITS ARRANGED BY NRC

PROGRAM FOR 1967

1. Eminent Scientists for visits up to one month

Dr. R.A. Abramovitch	University of Saskatchewan	Chemistry
Dr. G.L. Pickard	Institute of Oceanography, University of British Columbia	Oceanography
Dr. S.J. Bourget	Laval University	Soil Science
Dr. L. Dessureaux	Department of Agriculture	Forage Crops
Dr. M.B. Ives	McMaster University	Metallurgy
Dr. J.K.N. Jones	Queen's University	Chemistry
Dr. I. Takahashi	McMaster University	Biophysics
Dr. W. Opechowski	University of British Columbia	Physics

2. Research workers for visits up to one year

Dr. F. Claisse	Laval University	Metallurgy
Dr. C. Godin	University of Ottawa	Biology
Dr. K.G. Standing	University of Manitoba	Physics
Dr. B.P. Wisnicki	University of British Columbia	Architecture
Dr. D.E. Elrick	University of Guelph	Soil Science
Dr. J.A. Mandarino	Royal Ontario Museum, University of Toronto	Mineralogy
Dr. G.H. Schmid	University of Toronto	Chemistry
Dr. G. Talbot	Laval University	Biochemistry

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3. French Scientists invited to Symposia in Canada

Dr. G. Bessis	Second Canadian Symposium on Quantum Chemistry
Prof. Oudin	Canadian Society for Immunology - Immunological Aspects of Polymorphism
Prof. J. Chatonnet	Thermoregulation
Prof. M. Becart	NRC - Thirteenth International Colloquium on Spectroscopy
Dr. C. Peaud-Lenoel	Fourth International Conference on Carbohydrate Chemistry
Prof. M. Lelubre	Geological Association of Canada - Field Conference
Dr. J.J. Breusse	Associate Committee on Geodesy and Geophysics, Geological Survey of Canada - Canadian Centennial Conference on Mining and Groundwater Geophysics

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EXCHANGE AGREEMENT WITH FRANCE

VISITS ARRANGED BY NRC

PROGRAM FOR 1968

1. Eminent Scientists for visits up to one month

Dr. J.E. Desnoyers	University of Sherbrooke	Chemistry
Dr. J.W. Hodgins	McMaster University	Chemical Engineering
Dr. J.B.P. Kennedy	University of Windsor	Civil Engineering
Dr. J.G. Paquet	Laval University	Electrical Engineering
Dr. H.I. Schiff	York University	Kinetics
Dr. M.E. Spencer	University of Alberta	Plant Biochemistry
Dr. D.T. Suzuki	University of British Columbia	Genetics
Dr. W.K. Dawson	University of Alberta	Nuclear Physics
Dr. A.N. Sherbourne	University of Waterloo	Engineering

2. Research workers for visits up to one year

Dr. L.P. Blanchard	Laval University	Chemical Engineering
Dr. C.M. Boyd	Dalhousie University	Oceanography
Dr. A.D. May	University of Toronto	Physics
Dr. J.C. Richer	University of Montreal	Chemistry
Dr. J.P. Valleau	University of Toronto	Chemistry
Dr. G.A. Woonton	McGill University	Physics

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3. French Scientists invited to Symposia in Canada

Prof. L. Lliboutry	Seminar on the Causes and Mechanics of Glacier Surges
Mr. C.L. Lackme	International Symposium on Research in Cocurrent Gas-Liquid Flow
Dr. J. Villain	Banff Summer School on Critical Phenomena
Dr. G. Biozzi	NATO Advanced Study Institute on Cellular and Genetic Aspects of Antibody Formation
Prof. H. Benoit	International Union of Pure and Applied Chemistry - Macromolecular Chemistry Symposium
Dr. M. Clerc	International Symposium on Laboratory Measurements of Aeronomic Interest
Prof. J. Neveu	Seminaire de Mathematiques Superieure
Dr. J.P. Burger	Advanced Summer School on Super Conductivity
Mme C. Vermeil	Eighth Informal Conference on Photochemistry
(Name to be submitted later)	A.C.F.A.S. Assemblee Generale Annuelle

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Ottawa, August 29, 1968.

No. CA 1607

Excellency:

I have the honour to acknowledge with thanks receipt of your Note No. 48 of August 29, 1968, in which you propose that our two governments conclude an agreement with the object of improving scientific relations between our two countries by way of an exchange of notes.

The terms and conditions for the agreement set out in your note under reference have met with the complete approval of the Canadian Government. I therefore have the honour to propose that your note, together with this reply, the text of which is equally authentic in English and French, constitute an agreement between our two Governments which shall enter into force upon the date of this note.

Accept, Excellency, the renewed assurances of my highest consideration.

Secretary of State for
External Affairs.

Her Excellency Dora Alencar de Vasconcellos,
Ambassador of Brazil,
Ottawa.

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Ottawa, 29 August, 1968.

No. 48

Sir,

I have the honour to inform you that, further to discussions between the National Research Council of Brazil and the National Research Council of Canada, the Government of Brazil, with the objective of improving scientific relations between the two countries, has instructed me to propose that our two governments conclude an agreement by way of an exchange of notes in the following terms.

The National Research Council of Brazil will place at the disposition of the National Research Council of Canada, for the upkeep of Canadian scientists in Brazil, a sum in cruzeiros, and in turn, the National Research Council of Canada will place at the disposition of the National Research Council of Brazil, for the upkeep, in Canada, of Brazilian scientists, an equal sum in Canadian dollars, both sums convertible into United States dollars; and for reference puposes all accounts are to be kept in United States currency. For the two-year duration of the agreement, each Council shall place at the disposition of the other the sum of U.S. $20,000 per year. Thereafter, should this agreement be renewed, the two Councils shall agree on the sum each is to place at the disposition of the other per year.

Each contracting party will pay the expenses of transportation of its own scientists to and from the principal point of their stay in the other country, and will grant fellowships to, or otherwise provide living expenses for, the visiting scientists from the other country, such expenses being chargeable against the sum of money set aside by each of the Research Councils. Travel expenses for visiting scientists within the country visited will be paid by the host Council from the same fund.

Although in general visiting scientists will be expected to make their own arrangements with the institutions where they will carry out their research, each Research Council will formally obtain consent of the other for visits of its own scientists and will authorize use of the funds under Article 1 for support of said visits. When desirable the Research Councils will assist with arrangements for visits. The visits may be of two kinds:

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(1) Visits of Six months to one year to undertake research projects in laboratories, or,

(2) Visits of shorter periods of time to attend conferences, visit laboratories, conduct seminars or give lectures.

For visits under (1), expenses will be paid in the form of a fellowship equivalent to those awarded in that country to scientists of comparable status. For visits under (2) expenses will be paid on the basis of hotel plus per diem living expenses.

If one of the Councils does not within a given year utilize the total sum placed at its disposal by the other Council, the amount not utilized will be carried forward to the next year and will be available in addition to the amount otherwise agreed to for that year.

Each Council agrees to take the necessary steps to ensure that all publications put out under its auspices for general distribution be available to the other Council either through exchange or through other arrangements.

This agreement shall be in force for a period of two years, and thereafter until terminated by either party giving three months' notice in writing to the other. At the time of termination, the parties will conclude a separate arrangement for the disposal of any unexpended funds made available under paragraph one for the operation of the agreement.

If the above terms meet with your approval, I have the honour to propose that this note, together with your reply to that effect, constitute an agreement between our two Governments which will enter into force upon the date of your reply.

Please accept, Sir, the assurances of my highest consideration.

Dora Alencar de Vasconcellos,
Ambassador of Brazil.

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TYPICAL LIST OF CONFERENCES
AND
SYMPOSIA SUPPORTED BY GRANTS
IN ONE YEAR

Item	Location and No. of Participants	Awarded
C.A.P. Summer School "Quantum Optics	U.B.C. 60 participants (40 Canadians)	5,000
C.I.C. Symposium "Synthesis"	Banff 235 participants	1,500
C.I.C. Symposium "Inorganic Reaction Mechanisms"	U. of Toronto 8 invited speakers approximately 120 participants	750
C.I.C. Can. Biochem. Soc. International Symposium on Cell Membranes	Laurentians 100 - 120 participants	5,000
Canadian Societies Phytopathological Plant Physiologists Botanical	U.B.C. 250 participants	630
Meeting of American Society of Limnologists and Oceanographers M.O. Morgan Newfoundland	Memorial Univ. of Newfoundland	1,500
Canadian Association of Physicists - Theoretical Physics Div. B. Margolis McGill	"Nuclear & Particle Physics" McGill 5 invited lecturers 75 participants 7th School in a continuing series	5,000
Cold Physiology Conference	Ottawa University 60 participants	1,800

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Item	Location and No. of Participants	Awarded
D.B. Scott Computing Science Alberta "Time-sharing Session"	Banff 6 invited speakers	2,000
J.F. Heard David Dunlap Obser. Univ. of Toronto International Symposium "The Determination of Radial Velocities and their application"	Toronto University 50 participants	4,500
"Third International Conference on Atomic Masses" sponsored by I.U.P.A.P.	Manitoba 80 - 100 participants	5,000
Canadian Centennial Conference on Mining and Ground Water Geophysics: (organized by Subcomm. on Exploration Geophysics)	Niagara Falls Approx. 650 participants	10,000
Department of Mathematics Queen's Univ. Dr. A.J. Coleman	Queen's 30 - 50 participants (physicists, chemists, mathematicians)	3,000 (1967 only)
Chemical Institute of Canada, Analytical Chemistry Div.	Mt. Allison Univ. Symposium in conjunction with annual Meeting of Atlantic Section of C.I.C. 6 invited keynote speakers	1,250
Computer Science Association "Computer Science Research Seminar"	Toronto 3 lecturers 100 participants 75 Canadian 25 U.S.	3,000
George Setterfield Biology Carleton "6th International Conference on Plant Growth Substance"	Carleton University 150 participants	5,000 (2,500 recoverable from royalties)

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Item	Location and No. of Participants	Awarded
G. Herzberg Pure Physics NRC "International Conference on Deformation of Crystalline Solids	Ottawa 70 participants	7,500 to Royal Society
ACFAS 34th Congress	Laval U. 1200 participants	4,000
"Second Can. Symposium on Quantum Chemistry" C. Sandorfy M.A. Whitehead	U. of Montreal Speakers 12 European 20 North American	7,500
Fourth Inst. Conf. on Carbohydrate Chemistry J.M.N. Jones, Chm. C.T. Bishop, Gen. Secty.	Queen's U. 200 - 250 participants	7,000
Int. Conf. on Non-Aqueous Solvent Chemistry R.J. Gillespie	McMaster U.	4,500
Canadian Society for Immunology Didier Dufour Faculty of Medicine	Laval U. Minimum of 300 participants	2,000
Can. Congress of Applied Mechanics. I.P.J. Rémrott	Laval U. 200 participants	4,000
6th Int. Conf. on Cloud Physics	Toronto 300 - 400 participants	5,000
C.I.C.	Montreal	500
Meyer-Oakes June 1966	Manitoba	1,800
International Electronics Conference (Inst. of Electrical & Electronics Engineers)	Toronto 1965 Conference drew 11,000 visitors 100 formal technical papers	3,500
Canadian Operational Research Society - 9th Annual Conference	Ottawa 150 participants	Not to exceed 2,000

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Item	Location and No. of Participants	Awarded
Faraday Society "Molecular Dynamics of Chemical Reation" (3rd meeting in Canada)	Toronto 200 registrants plus graduate students and others	6,000
Geological Assoc. of Canada Mineralogical Assoc. of Canada. Field Conference jointly with AZOPRO and Mineralogical Society of America at time of Annual Meeting.	Queen's 500 - 1000 participants in annual meeting Registration fee $8.00 Approx. 50 participants in field conference at a charge of $180.00 each.	7,500
L'Abbé Mathematics Montreal University International Seminar on Higher Mathematics	Montreal University 100 participants in 1964	20,000
Cold Physiology Conference, Alberta Cottle, W.H.	U. of Alberta 40 participants	(1,500
Cold Thermogenesis	U. of Alberta 40 participants	(
Ninth International Symposium on Free Radicals	Banff School of Fine Arts 150 participants (50 from outside North America)	15,000
Thirteenth Radar Meteorology Conf.	McGill Univ. 300 participants	1,600
Department of Physics McGill Stevenson, D.R.	"A review of the foundations of the theory of magnetism" Director: A.J. Freeman MIT Nat. Magnet Lab.; Lecturers from U.S. and Great Britain 75 - 100 participants	5,000

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(a) TOTALS BY CATEGORY OF PERSONNEL

APRIL 1, 1968

Table 1

Professional:	
Scientific Research	607
Post Doctoral Fellows	181
Scientific Services	102
Technicians:	
Technical (Laboratory)	721
Technical (Services)	399
Other Supporting Personnel:	
General Service Staff	587
Stenos & Typists	200
Plant Craftsmen and Maintenance Staff	242
Total	3039

(b) Number of Scientific Professional Staff devoting most of their time to Administrative duties (not including Scientific Services Staff)

Total 16

Table 2

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(c)

COUNTRY	Ph.D. (483) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree	Master (165) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree	Bachelor (140) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree
Australia	7	9	7	1	1	1	5	6	6
Austria	4	2	1	2	2	2	1	-	-
Belgium	1	1	1	2	2	1	-	-	-
British Guiana	1	-	-	-	-	-	-	-	-
Canada	172	190	131	90	97	83	81	95	98
Ceylon	2	2	-	-	-	-	1	-	-
China	4	1	-	1	1	-	1	1	-
Czechoslovakia	15	14	14	1	1	1	1	-	-
Denmark	1	-	-	1	-	-	-	-	-
Egypt	2	2	1	-	-	-	-	-	-
England	93	88	137	16	14	22	27	26	27
Estonia	1	-	-	-	-	-	1	-	-
Finland	2	2	1	1	1	1	-	-	-
France	4	5	4	-	-	-	1	-	-
Germany	10	9	11	4	3	2	2	2	3
Greece	3	3	-	-	-	-	1	1	-
Hong Kong	8	6	-	1	1	-	-	-	-
Hungary	6	6	2	2	2	1	2	-	-
India	32	31	24	1	2	1	1	1	-
Indonesia	1	-	-	1	1	-	1	-	-
Iraq	1	-	-	1	1	-	-	-	-
Ireland	3	2	3	2	2	2	-	-	-
Israel	1	2	1	-	-	-	-	-	-
Italy	3	3	2	2	2	2	-	-	-
Jamaica	-	-	-	1	-	-	-	-	-
Japan	20	21	20	1	1	1	1	1	1
Korea	3	4	-	-	-	-	-	-	-
Latvia	-	-	-	1	1	-	-	-	-
Lithuania	-	-	-	1	1	-	-	-	-
Netherlands	8	5	5	6	6	7	1	-	-
New Zealand	6	6	3	2	2	1	-	-	-
Norway	-	-	-	-	-	-	1	1	-
Pakistan	3	3	1	1	-	-	-	-	-
Poland	15	10	6	8	7	7	-	-	-

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Table 2

(c)

COUNTRY	Ph.D. (483) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree	Master (165) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree	Bachelor (140) (i) of Birth	(ii) of Sec'y Ed'n	(iii) of Degree
Romania	2	1	-	-	-	-	-	-	-
Scotland	17	22	20	3	2	-	5	4	3
South Africa	2	2	2	1	1	1	-	-	-
Sweden	2	3	2	2	3	3	-	-	-
Switzerland	3	3	5	4	4	3	-	-	-
Taiwan	1	2	-	2	2	-	-	-	-
Tasmania	1	-	-	-	-	-	-	-	-
Trinidad	2	2	1	-	-	-	-	-	-
Tunisia	1	-	-	-	-	-	-	-	-
Turkey	1	2	-	-	-	-	-	-	-
U.S.A.	9	10	72	1	1	22	6	2	2
U.S.S.R.	3	2	2	1	-	-	-	-	-
Vietnam	1	1	-	-	-	-	-	-	-
Yugoslavia	6	6	4	1	1	1	-	-	-

Table 3

(c) (cont'd)

		Ph. D.	Master	Bachelor
(iv)	Average number of working years since graduation	9.3	12.8	17.2
	Average number of years at NRC	7.4	9.8	12.7
(v)	Average Age	37.7	39.9	41.3
(vi)	Percent Bilingual	15%	21%	13%

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(d) TOTALS IN EACH DEGREE CATEGORY
(including Postdoctorate Fellows
but not including Scientific Services)

Table 4

	Ph. D.	Master	Bachelor
1962-3	349	144	180
1963-4	342	144	160
1964-5	362	166	150
1965-6	381	170	151
1966-7	427	164	144
1967-8	483	165	140

(e) TURNOVER

(Percent of Scientific Staff
leaving the organization)

Table 5

	Incl. PDF's	Not Incl. PDF's
1962-3	16.2%	2.8%
1963-4	19.3%	2.1%
1964-5	14.8%	3.9%
1965-6	16.2%	4.7%
1966-7	15.5%	3.7%
1967-8	17.4%	3.5%

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(f) Table 6

Percent of Scientific Staff who, since graduation, were:	Ph. D.	Master	Bachelor
(i) Employed by industry at one time	16.1%	37.6%	39.3%
(ii) On the staff of universities	33.1%	47.9%	36.4%
(iii) Employed by provincial dept's or agencies	-	3.0%	5.0%
(iv) Employed by other Federal agencies	3.1%	7.3%	16.4%

(g) NUMBER OF STAFF IN EACH DEGREE CATEGORY ON EDUCATION LEAVE

1 April 1968

Table 7

Bachelor	Ø
Master	7
Doctor	Ø

(h) NUMBER OF UNIVERSITY STUDENTS GIVEN SUMMER EMPLOYMENT

Table 8

1962	131
1963	131
1964	128
1965	122
1966	138
1967	140
1968	121

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FORMER SCIENTIFIC AND ENGINEERING STAFF
WHO NOW HOLD SIGNIFICANT POSITIONS
IN OTHER AREAS OF ACTIVITY

The following are designed to be illustrative of the number and diversity of areas and activities where N.R.C. "Alumni" can be found:

a) Attachment I - There are over 100 former N.R.C. scientific and engineering staff currently employed by Canadian Universities. Examples of some of those holding more senior positions are listed. There are also approximately 70 former Postdoctorate Fellows employed in Canadian Universities.

b) Attachment II - There are just under 100 recorded former N.R.C. scientific and engineering staff who we believe are employed in Canadian industry at this time. Examples are listed. Approximately 50 former Postdoctorate Fellowships holders are also now to be found employed in Canadian industry.

c) Attachment III - In addition to about 40 Postdoctorate Fellows now employed with the Federal Government, a number of former N.R.C. scientific and engineering staff are to be found in other Federal Departments and Agencies. Large numbers of the existing staff of Atomic Energy of Canada

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Limited and the Defence Research Board were of course employees of the National Research Council before these organizations were separated from N.R.C. and set up as separate agencies. Examples of former N.R.C. employees in departments other than A.E.C.L. and D.R.B. are listed.

d) Attachment IV - Of some 110 former N.R.C. scientific and engineering staff now employed abroad (including U.S.A.), examples of the geographic and occupational variety can be observed from the attached examples.

e) Attachment V - A record was found of some 375 N.R.C. Postdoctorate Fellows now employed all over the world. A sample of the whereabouts of 24, in unedited consecutive alphabetical order, is provided.

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Attachment I
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NATIONAL RESEARCH COUNCIL OF CANADA

Former Scientific and Engineering Staff
Who Now Hold Significant Positions
in
UNIVERSITIES
in Canada

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Amberg, C.H.	9	1964	Prof., Chemistry, Carleton.
Baines, W.D.	8	1959	Prof., Mech. Eng., Toronto.
Bayley, S.T.	15	1967	Head, Dept. of Biology, McMaster.
Bell, R.E.	3	1945	Vice-Dean, Physical Sciences, McGill.
Betts, R.H.	7	1952	Prof. and Head, Dept. of Chem., Manitoba.
Blackwood, A.C.	$8\frac{1}{2}$	1957	Prof. and Chairman, Dept. of Microbiology, Macdonald Coll.
Boulet, M.A.	15	1962	Prof., Agric., Laval.
Dacey, J.R.	5	1945	Prof., Chem., Royal Military College.
Duckworth, H.E.	2	1945	Vice-President (Academic), Manitoba.
Fischer, G.	6	1962	Prof., Physics, Montreal.
Gunning, H.E.	4	1943	Prof. and Head, Dept. of Chemistry, Alberta.
Hart, J.	4	1957	Dean of Science, Lakehead.
Heyding, R.D.	8	1962	Prof., Chemistry, Queen's.
Hodgins, J.W.	5	1945	Dean of Engineering, McMaster.
Johnson, L.P.V.	18	1946	Prof., Genetics, Alberta.

Appendix L
Attachment I
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Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Lemieux, R.U.	5	1954	Prof., Chem., Alberta, and Head, R & L Molecular Research Lab., Edmonton.
LeRoy, D.J.	5	1944	Chairman, Dept. of Chemistry, Toronto.
Marion, L.	35	1965	Dean of Pure and Applied Science, Ottawa.
Milsum, J.H.	10	1961	Prof., Control Engineering, McGill.
Perlin, A.S.	12½	1967	E.B. Eddy Chair of Chemistry, McGill.
Pidgeon, L.M.	7	1938	Prof., Metallurgy and Head of Department, Toronto.
Rose, D.C.	36	1966	Prof., Physics, Carleton.
Rosser, F.T.	30	1967	President, Algonquin College.
Setterfield, G.A.	6	1962	Prof. and Chairman, Dept. of Biology, Carleton.
Wilson, B.G.	3	1960	Dean of Arts and Science, Calgary.
Winkler, C.A.	4	1940	Vice-Principal, Planning and Development, McGill.

Appendix L
Attachment II
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NATIONAL RESEARCH COUNCIL OF CANADA

Former Scientific and Engineering Staff
Who Now Hold Significant Positions
in
INDUSTRY
in Canada

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Bell, J.W.	8	1945	Vice-President, Research and Development, CAE Industries Ltd.
Borth, L.A.	2	1950	Director of Engineering, Litton Systems (Canada).
Cox, W.J.	9	1951	Chief Test Engineer, Massey-Ferguson.
Dilworth, P.	4	1946	President, Dilworth, Secord, Meagher and Associates.
Evans, R.S.	5	1956	Director of Research, Columbia Cellulose Co. Ltd., Vancouver.
Gallay, W.	11	1943	Director of Research, E.B. Eddy Co.
Gishler, P.E.	19	1955	Director of Research, Canadian Chemical Co., Edmonton.
Grace, Norm.	1	1938	General Manager, Dunlop Res. Centre, Toronto.
Green, J.J.	12	1942	Vice-President, Litton Systems (Canada)
Hiscocks, R.D.	3	1946	Director, Future Projects and Planning, DeHavilland Aircraft of Canada.
Kenalty, B.J.	10	1942	President, Kenalty Industries Ltd.
Howlett, L.E.	37	1968	President, Space Optics, Ottawa.
Mounce, G.R.	$4\frac{1}{2}$	1945	Chief Engineer, Electronic Associates, Toronto.

Appendix L
Attachment II
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Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Nazzer, D.B.	12	1956	Manager, Heavy Water Projects, Canadian General Electric Co., Port Hawkesbury, N.S.
Phibbs, M.K.	5	1951	Head of Research, DuPont of Canada, Kingston, Ont.
Phillips, N.W.F.	4	1941	Head, Electrometallurgical Div., Aluminum Laboratories Ltd., Arvida.
Manske, R.H.F.	12	1944	Retired Director of Research, Uniroyal, Guelph.
Sacks, W.	3	1952	Director of Research, Allied Chemicals.
Smith, E.	7	1957	Vice-President, Engineering, United Aircraft of Canada Limited.
Stephenson, T.E.	14	1956	President, United Aircraft of Canada Limited.
Uffen, J.P.	6	1951	Chief Aerodynamicist, DeHavilland Aircraft (Canada).

Appendix L
Attachment III
-1-

NATIONAL RESEARCH COUNCIL OF CANADA

Former Scientific and Engineering Staff
Who Now Hold Significant Positions
in
FEDERAL DEPARTMENTS AND
AGENCIES

Name	No. of Yrs. at N. R. C.	Yr. Left N. R. C.	Last Known Position or Affiliation
Anderson, J. A.	9	1939	Director General, Research Br., Canadian Department of Agriculture, Ottawa (Retired)
Baxter, D. C.	13	1965	Chief, Applications Division, Central Data Processing Service Bureau, Ottawa.
Farmilo, C. G.	2	1946	Head, Organic Chemistry and Narcotics Section, Food and Drug Directorate, Ottawa.
Hochster, R. M.	5	1956	Director, Cell Biology Research Inst., Research Branch, Can. Dept. of Agriculture, Ottawa.
Hoey, G.	8	1960	Group Leader, Corrosion, Energy, Mines and Resources.
Hughes, E. O. W.	5	1956	Adviser, Science Secretariat, Ottawa.
Laurence, G. C.	23	1955	President, Atomic Energy Control Board.
Neu, H.	13	1967	Bedford Institute of Oceanography.
Orr, J. L.	15	1955	Industrial Research Adviser, Department of Industry.
Petersen, E. R.	7	1967	Senior Analyst, Mathematical Programming Division, Operators Research Branch, National Energy Board.

Appendix L
Attachment III
-2-

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Pocock, P. J.	18	1964	Director of Research, Senate Special Committee on Science Policy.
Prince, A. T.	2	1942	Director, Inland Waters Branch, Department of Energy, Mines and Resources, Ottawa.
Quarterman, C. D.	13	1954	Chief, Electronics Division, Aerospace Branch, Department of Industry.
Sims, R.P.A.	5	1954	Director, Food Research Inst., Research Branch, Canadian Department of Agriculture, Ottaw
Thomas, J. F. J.	7	1943	A/Chief, Water Quality Division, Energy, Mines and Resources.
Wadsworth, J.	9	1968	Treasury Board.
Wright, G. M.	6	1952	Senior Scientist, Geology Div., Energy, Mines and Resources.

Appendix L
Attachment IV
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NATIONAL RESEARCH COUNCIL OF CANADA

Former Scientific and Engineering Staff
Who Now Hold Significant Positions
ABROAD
(Incl. U.S.A.)

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Barron, T.H.K.	$1\frac{1}{2}$	1958	Prof., Dept. of Physical and Inorganic Chem., The University, Bristol, U.K.
Bauer, H.	4	1956	Group Leader, Kalle A. G. Wiesbaden, W. Germany.
Baxter, R.M.	10	1962	Faculty of Science, University College, Ethiopia.
Beveridge, H.N.	4	1945	Vice-President, General Research Corp., Santa Barbara.
Bidwell, R.G.S.	3	1959	Professor and Chairman, Dept. of Biology, Case Western Reserve University, Cleveland, Ohio.
Brown, A.G.	16	1954	Senior Director, Stanford Research Institute, Menlo Park, California.
Brunton, D.C.	4	1945	Manager, Nuclear Radiation Dept. Curtis Wright Corp., N.J.
Charlwood, P.A.	3	1956	Medical Research Council, Mill Hill, London, England.
Darwent, B. de B.	8	1952	Prof. of Chemistry, Catholic University of Washington.
Dugdale, J.S.	14	1965	Prof., Dept. of Physics, Univ. of Leeds, England.
Falconer, W.E.	2	1963	Group Leader, Bell Telephone Company.
Fenton, S.W.	1	1947	Prof. and Chairman, Dept. of Chemistry, Univ. of Minnesota
Happe, W.H. (Jr.)	4	1945	President, Research Enterprises, Inc., Nutley, N.J.

Appendix L
Attachment IV
-2-

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Harwood, V.D.	3	1952	Forest Research Institute, New Zealand Forest Service, Rotorva, New Zealand.
Helava, U.V.	12	1965	Head, Research, Ottico Mecannica Rome, Italty.
Jarlan, G.	11	1967	Consulting Engineer, Paris, France.
Jones, D.C.	3	1940	Vice-President, American Optical Co.
Lama, R.	3	1958	Prof. of Chem. Eng., Peru.
Lovejoy, D.R.	12	1966	United Nations Development Prog., New York. Scientist.
Marcon, L.J.	$3\frac{1}{2}$	1956	Civil Engineering Construction, recently with large firm in Africa.
McKay, K.G.	4	1945	Vice-President, American Telephone and Telegraph.
Murphy, D.	9	1956	Research and Technology Survey, Dept. of Industry and Commerce, Dublin.
Papee, H.M.	2	1960	Centre for ACROSO/Nucleation, N.R.C. of Italy.
Qurashi, M.M.	1	1963	Chief Scientist and Scientific Adviser to Ministry of Defence, Defence Science Organization, West Pakistan.
Ritter, G.J.	3	1964	Section Leader, CSIRO, Pretoria, S. Africa.
Shu, Ping	7	1956	Senior Research Chemist, Lederle Labs. Division American Cyanamid Co., Pearl River, N.Y.

Appendix L
Attachment IV
-3-

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Smith, A.W.	2½	1960	Dept. of Public Works, New Zealand.
Smith, J.E.	4	1953	International Sales Manager, Continental Engines Ltd., Detroit.
Stanier, R.Y.	2	1944	Head, Dept. of Bacteriology, Univ. of California, Berkeley, Calif.
Thorn, J.A.	3½	1953	Manager of Laboratories, Yeast Division, Red Star Yeast and Products Co., Milwaukee, Wisc.
Venkateswarlu, P.	1	1968	Senior Professor, Indian Institute of Technology, Kanpur, India.
Whealy, J.E.	3	1945	Assist. Chief Engineer, Oceanics, Bendix Corp., North Hollywood.
White, G.K.	3	1958	Section Head, Division of Physics, National Standards Laboratory, Chippendale, N.S.W., Australia.

Appendix L
Attachment V
-1-

NATIONAL RESEARCH COUNCIL OF CANADA

Former Postdoctorate Fellows
Who Now Hold Significant Positions
ABROAD
(Incl. U.S.A.)

Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Augustyniak, J. Z.	1½	1963	Pl. Warynskicgo 8m8, Poznan, Poland.
Ausloos, P.	2	1954	Chemist, Photochemistry and Radiation Chemistry, National Bureau of Standards, Washington.
Avery, H. E.	3	1966	Lecturer, Liverpool Regional Coll. of Technology, Liverpool, England.
Awano, M.	1	1962	Senior Scientist, University of Tokyo, Japan.
Balazs, N.	1	1953	Professor of Physics, State Univ. of New York, Stony Brook.
Ball, D.H.	2	1958	U.S. Army Labs., Natick, Mass.
Bandack Yuri, S.	2	1960	Domingo F. Sarmienta 28, Santiago, Chile.
Barron, T.H.K.	2	1957	Professor, Dept. of Physical and Inorganic Chemistry, The University, Bristol, U.K.
Bartha, L.	1½	1964	University in Debrecen, Hungary.
Basu, S.N.	1	1952	Indian Jute Mills Assoc. Res. Inst. Calcutta, India.
Bauer, E.	2	1952	Inst. of Mathematics and Mechanics, New York University.
Beer, M.	2	1958	Dept. of Biophysics, Johns Hopkins University, Baltimore.

Appendix L
Attachment V
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Name	No. of Yrs. at N.R.C.	Yr. Left N.R.C.	Last Known Position or Affiliation
Benton, D.P.	2	1955	Senior Lecturer, University of Surrey, England.
Bernardi, G.	2	1959	Institut de Biologie Moleculaire, Paris, France.
Boocock, G.	1	1958	Research Officer, Shell Chemical Co., Partington, Manchester, Eng.
Booker, C.J.L.	1	1962	Metallurgy Dept., Sir John Cass College, London, England.
Boring, J.R.	1	1962	Epidemiology Branch, Communicable Disease Center, Atlanta, Ga.
Bovey, L.E.H.	2	1952	Staffordshire, England.
Brinton, R.H.	1	1955	Professor, Dept. of Chemistry, Univ. of California.
Broniewski, A.	1	1950	Paris, France.
Buob, K.H.	2	1958	Corrosion & Materials Group, Reactor Ltd. of Switzerland, Zurich.
Burchill, P.J.M.	2	1966	The University College, Cardiff, Wales.
Burley, R.W.	2	1961	C.S.I.R.O., Division of Food Preservation, Australia.
Burma, D.P.	1	1955	Bose Research Institute, Calcutta, India.

Appendix M
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NATIONAL RESEARCH COUNCIL OF CANADA

(excluding the Medical Research Council)

Regional Pattern of Agency's Spending
1967-68 (Millions of Dollars)

Region	Research Grants & Scholarships	Intramural Operations	Capital	Total
Atlantic Provinces	3.0	1.3	1.1	5.4
Quebec	9.9	(i)	-	9.9
Ontario				
Ottawa - Operations & Capital	-	37.2 (ii)	7.2	44.4
Ontario - Grants & Scholarships	20.8	-	-	20.8
Prairie Provinces	8.3	5.3	1.1	14.7
British Columbia	5.9	(i)	-	5.9
Outside Canada	1.2	-	-	1.2
Unlisted (iii)	1.8	-	-	1.8
Totals	50.9	43.8	9.4	104.1

Notes:

(i) Amount less than $50,000.

(ii) Amounts include $23.1 million for salaries spent in, and $14.1 million for contracts originating from, the National Capital area.

(iii) Information as to regional pattern of spending not readily obtainable from records.

Appendix M

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NATIONAL RESEARCH COUNCIL OF CANADA
(excluding the Medical Research Council)

Expenditures Associated with Scientific Activities
(Millions of Dollars)

	Expenditures						Estimates
	62-63	63-64	64-65	65-66	66-67	67-68	68-69
I - Functions							
(1) Intramural R & D	24.1	25.5	25.9	30.6	37.4	42.3	45.8
(2) Data Collection	.2	.2	.2	.2	.2	.3	.3
(3) Scientific Information	1.9	1.9	2.0	3.3	4.2	4.5	5.0
(4) Testing & Standardization	1.2	1.3	1.3	1.6	1.7	1.9	2.1
(5) Support of R & D in Industry	.5	1.5	2.2	3.3	4.2	5.1	6.1
(6) Support of R & D in Universities	9.0	10.6	15.2	19.1	30.4	40.7	51.4
(7) Research Scholarships and Fellowships	1.5	1.9	2.2	3.0	4.3	5.6	8.9
Total	38.4	42.9	49.0	61.2	82.4	100.4	119.6
II - Scientific Discipline							
(1) Engineering & Technology	11.2	12.7	14.0	16.4	21.2	25.6	
(2) Natural Sciences: (Basic & Applied)							
(a) Agricultural	.8	.9	1.2	1.6	2.3	2.9	
(b) Astronomy	1.1	1.1	1.4	1.5	1.8	2.0	
(c) Atmospheric	-	-	.1	.2	.8	1.0	
(d) Biological	3.3	3.9	4.8	5.8	8.0	10.3	
(e) Chemistry	5.8	6.5	7.4	9.3	12.6	15.6	
(f) Mathematics	.2	.2	.4	.9	1.8	2.3	
(g) Medical	.6	.9	1.2	1.3	2.0	2.5	
(h) Oceanography	.3	.3	.4	.8	1.2	1.5	
(i) Physics	8.5	9.3	9.8	12.5	17.1	20.4	
(j) Solid Earth Sciences	1.8	1.8	2.6	2.8	3.2	4.0	
(3) Social Sciences	-	-	-	-	-	-	
Sub-Total	33.6	37.6	43.3	53.1	72.0	88.1	103.3
(4) Unclassified (Note 2)	4.8	5.3	5.7	8.1	10.4	12.3	16.3
Total	38.4	42.9	49.0	61.2	82.4	100.4	119.6

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Appendix M
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Appendix M
- 3 -

NATIONAL RESEARCH COUNCIL OF CANADA
(excluding the Medical Research Council)

Expenditures Associated with Scientific Activities
(Millions of Dollars)

III - Areas of Application	Expenditures 62-63	63-64	64-65	65-66	66-67	67-68	Estimates 68-69
(1) Nuclear Energy	.3	.3	.3	.3	.3	.4	
(2) Space Communications	-	-	.1	.2	.9	1.2	
(3) Defence	5.2	2.7	2.5	2.2	2.0	2.0	
(4) Agriculture	-	.1	-	.1	.2	.2	
(5) Construction	2.3	2.5	2.5	2.9	2.8	3.4	
(6) Transportation	1.6	1.7	2.6	3.3	4.7	5.4	
(7) Telecommunications	-	-	-	-	.7	.6	
(8) Health	.2	.4	.3	.4	.2	.2	
(9) Industry	5.4	9.3	10.0	11.2	11.6	13.8	
(10) Regional Development	1.7	1.7	1.9	2.1	2.6	2.9	
(11) Basic Research - Extramural	8.4	9.7	14.3	18.0	30.2	39.7	
- Intramural	8.5	9.2	8.8	12.4	15.8	18.3	
Sub-Total	33.6	37.6	43.3	53.1	72.0	88.1	103.3
(12) Unclassified (Note 2)	4.8	5.3	5.7	8.1	10.4	12.3	16.3
Total	38.4	42.9	49.0	61.2	82.4	100.4	119.6

Note 1 - Figures used in tables are cross expenditures and do not reflect separately those offset by Revenues, Contributions, and Recoveries.

Note 2 - Expenditures for Data Collection, Scientific Information, Testing & Standardization, and support for Research Scholarships and Fellowships are not classified as to scientific discipline or area of application.

NATIONAL RESEARCH COUNCIL OF CANADA

OPERATING AND CAPITAL EXPENDITURES
(MILLIONS OF DOLLARS)

Organizational Unit	Operations or Capital	Expenditures 62-63	63-64	64-65	65-66	66-67	67-68	Estimates 68-69
Laboratories								
Applied Chemistry	Ops.	1.32	1.36	1.48	1.66	1.79	2.14	2.23
	Cap.	-	-	.06	.07	.08	.10	.03
Applied Physics	Ops.	1.70	1.66	1.89	2.06	2.33	2.67	3.02
	Cap.	.25	.05	.05	.57	1.75	.67	.33
Atlantic Regional Laboratory	Ops.	.47	.53	.63	.71	1.02	1.18	1.31
	Cap.	.02	.02	.12	.07	1.32	1.14	.31
Biochemistry and Molecular Biology	Ops.						(ii)	.07
	Cap.						(ii)	.02
Biology	Ops.							(ii)
	Cap.							(ii)
Biosciences	Ops.	1.07	1.05	1.15	1.27	1.43	1.64	1.75
	Cap.	.07	.01	.02	.09	.09	.03	.03
Building Research	Ops.	1.97	2.02	2.20	2.24	2.59	2.95	3.27
	Cap.	-	-	.02	.41	.15	.09	.55
Mechanical Engineering	Ops.	3.24	3.14	3.46	3.64	4.12	4.48	4.81
	Cap.	.15	.19	.22	.64	.22	.18	.22
National Aeronautical Establishment	Ops.	1.72	1.91	1.95	2.20	2.56	2.89	3.09
	Cap.	.25	.54	.36	.42	1.25	3.79	1.84
Prairie Regional Laboratory	Ops.	.82	.79	.88	.96	1.09	1.15	1.25
	Cap.	.01	-	.01	.02	-	.36	.02
Pure Chemistry (ii)	Ops.	1.11	1.08	1.14	1.26	1.40	1.61	1.69
	Cap.	.04	.02	.02	.03	.03	.02	.03
Pure Physics (ii)(iii)	Ops.	1.42	1.55	1.59	1.65	1.97	2.27	2.48
	Cap.	.08	.07	.13	.09	.06	.02	.03
Radiation Biology	Ops.	-	-	.05	.20	.23	.31	.55
	Cap.	-	-	-	.06	.42	1.91	.50
Radio & Electrical Engineering (iii)	Ops.	3.59	3.63	3.90	4.10	4.48	4.81	5.20
	Cap.	.73	1.27	1.94	1.70	.82	.19	.09
Space Research Facilities Branch	Ops.	-	-	(iii)	2.66	5.17	6.05	6.59
	Cap.	-	-	(iii)	.01	.27	.68	.57
Sub-Total	Ops.	18.43	18.69	20.32	24.61	30.18	34.15	37.29
	Cap.	1.60	2.17	2.95	4.18	6.46	9.18	4.57

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Industrial Research Assistance & Promotion (including Technical Information Service)								
Sub-Total	Ops.	-	(iv)	.51	.60	.73	.84	1.01
	Cap.	-	-	-	.01	-	-	-
University Grants and Scholarships								
Awards Program for support of University Research (v)	Ops.	.53	.09	.12	.16	.23	.29	.35
	Cap.	-	-	-	-	-	-	-
Canadian Journals of Research	Ops.	(v)	.51	.57	.69	.89	1.09	1.63
	Cap.	-	-	-	-	-	-	-
International Relations (vii)	Ops.	-	(iv)	.26	.30	.32	.37	.37
	Cap.	-	-	-	-	-	-	.01
Associate Committee Secretariat (viii)								
Sub-Total	Ops.	.53	.60	.95	1.15	1.44	1.75	2.35
	Cap.	-	-	-	-	-	-	.01
Administration and Services								
Administration & Personnel (vi)	Ops.	1.52	1.60	1.90	1.29	1.51	1.69	1.90
	Cap.	.33	1.91	1.11	.17	.08	.12	.08
Plant Engineering Services	Ops.	1.58	1.75	1.75	2.39	2.63	2.85	3.05
	Cap.	.02	.01	.12	.36	.24	.08	.22
Computation Centre	Ops.	-	-	.16	.29	.47	.86	1.30
	Cap.	-	-	.07	1.18	.10	(i)	.13
Information Branch	Ops.	1.29	1.35	(iv)				
	Cap.	-	.01	-				
National Science Library	Ops.	-	(iv)	.63	.76	.98	1.07	1.17
	Cap.	-	-	-	.01	.03	.07	.13
Other (Administrative) Planning Service, Financial Services General Counsel)	Ops.	-	-	(vi)	.17	.21	.23	.23
	Cap.	-	-	-	-	-	-	-
Sub-Total	Ops.	4.39	4.70	4.44	4.90	5.80	6.70	7.65
	Cap.	.35	1.93	1.30	1.72	.45	.27	.56
Long-Term Policy and Planning (including Economic Studies)								
Sub-Total	Ops.	-	-	-	-	-	(vii)	.20
	Cap.	-	-	-	-	-	-	-

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Executive Offices (including Information Services)									
	Sub-Total	Ops.	-	-	(vi)	.48	.59	.38	.48
		Cap.	-	-	-	-	-	-	-
	TOTAL	Ops.	23.35	23.99	26.22	31.74	38.74	43.82	48.98
		Cap.	1.95	4.10	4.25	5.91	6.91	9.45	5.14

Notes

(i) Amounts of less than $5,000 are not shown in this table.

(ii) During 1968-69 two new Divisions were being organized (1) Biochemistry and Molecular Biology; (2) Biology) by a rearrangement of the Divisions of Biosciences and R Radiation Biology and a transfer of parts of the Divisions of Pure Chemistry and Pure Physics. Other reorganizations are in prospect.

(iii) Effective 1965-66 the Space Research Facilities Branch took over form the U.S. Government, control of the Churchill Research Range, and the expenditures relating to some activities of the Divisions of Pure Physics and Radio & Electrical Engineering have been consolidated in those for the new Branch.

(iv) Prior to 1964-65 amounts for Technical Information Service, International Relations and N National Science Library are included with Information Branch under Administration and Services.

(v) Prior to 1963-64 amounts for Canadian Journals of Research are included with Awards Program

(vi) Prior to 1965-66 amounts for Administrative Planning Service, Financial Services, General Counsel and Executive Offices are included with Administration and Personnel.

(vii) Prior to 1968-69 amounts for Economic Studies are included with International Relations.

(viii) Associate Committee Secretariat provided by Administrative Planning Service staff.

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NATIONAL RESEARCH COUNCIL OF CANADA

Funds expended to further professional university education of staff

Year	Amount ($000)
1962-63	17.5 *
1963-64	21.8 *
1964-65	39.6 *
1965-66	35.9 *
1966-67	32.2
1967-68	43.3
1968-69	35 Forecast

*Included is 3% to cover travel costs and tuition fees for which summary records are no longer available.

First Session—Twenty-eighth Parliament
1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
SPECIAL COMMITTEE
ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*
The Honourable DONALD CAMERON, *Vice-Chairman*

No. 4

THURSDAY, OCTOBER 24th, 1968

WITNESSES:

Department of National Defence: Dr. R. J. Uffen, Chairman, Defence Research Board; Dr. L. J. L'Heureux, Vice-Chairman, Defence Research Board; J. D. Houlding, Member, Defence Research Board and President of R.C.A. Victor Ltd.; and Major-General D. A. G. Waldock, Deputy Chief of Technical Services for Engineering of the Canadian Armed Forces.

APPENDICES:

3. Brief submitted by the Department of National Defence regarding Defence Research Board Activities.
4. Brief submitted by the Department of National Defence regarding Armed Forces Activities.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29099—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDER OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

29099—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

THURSDAY, October 24, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Bourget, Cameron, Grosart, Hays, Kinnear, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Robichaud, Thompson and Yuzyk—(15).

Present but not of the Committee: The Honourable Senators Carter and Giguère—(2).

In attendance:

Philip Pocock, Director of Research (Physical Science).

The following witnesses were heard:

DEPARTMENT OF NATIONAL DEFENCE:

Dr. R. J. Uffen, Chairman, Defence Research Board;
Dr. L. J. L'Heureux, Vice-Chairman, Defence Research Board;
J. D. Houlding, Member, Defence Research Board and President of R.C.A. Victor Ltd.

(*A curriculum vitae of each witness follows these Minutes.*)

At 12.45 p.m. the Committee adjourned until 3.30 p.m. this day.

AFTERNOON SITTING

The Committee resumed at 3.30 p.m., the Chairman, Senator Lamontagne, presiding.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Grosart, Hays, Kinnear, Leonard, MacKenzie, O'Leary (*Carleton*), Robichaud, Thompson and Yuzyk—(13).

Present but not of the Committee: The Honourable Senator Giguère—(1).

In attendance:

Philip Pocock, Director of Research (Physical Science).

The following witness was heard:

DEPARTMENT OF NATIONAL DEFENCE:

Major-General D. A. G. Waldock, Deputy Chief of Technical Services for Engineering of the Canadian Armed Forces.

(*A curriculum vitae of the witness follows these Minutes.*)

The witnesses heard at the morning meeting were further questioned.

The following are printed as appendices:

3. Brief submitted by the Department of National Defence regarding Defence Research Board Activities.
4. Brief submitted by the Department of National Defence regarding Armed Forces Activities.

At 5.25 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Uffen, Dr. Robert James, B.A.Sc., M.A., Ph.D., D.Sc., P.Eng., F.R.S.C., F.G.S.A. Dr. Uffen was born in Toronto in 1923. He attended primary and secondary schools in that City, graduating from Danforth Technical School in 1940. At the age of 18, he volunteered for the Canadian Army and served in the Royal Canadian Artillery (Radar). He retired after the second world war as a lieutenant. Dr. Uffen then attended the University of Toronto and received a B.A.Sc. in Engineering Physics in 1949. After a year of post-graduate studies at the same University, he obtained the M.A. in Geophysics. Two years later, after further post-graduate studies at the University of Western Ontario, he obtained a Ph.D. in Physics. Dr. Uffen was the recipient of a number of awards, among them, Research Council of Ontario Scholarships during the years 1950-52 and a Research Fellowship with the Institute of Geophysics at the University of California in 1953. While working towards his Doctorate, Dr. Uffen was a lecturer at the University of Western Ontario, and during the period 1953-57 was Assistant Professor of Physics and Geology. The following year he was named Associate Professor of Geophysics, and in 1958 he became Professor and Head of the Department of Geophysics. In July, 1960 he was also named Acting Head of the Department of Physics and, at the same time, assumed the responsibilities of Assistant Principal of the University College of Arts and Science. For the next four years he was Principal of University College and in 1965 was named first Dean of the College of Science. Dr. Uffen has published a number of original scientific papers in such diverse fields as operations research, volcanology and evolution. He is a member of the Society of Exploration Geophysicists; the Association of Professional Engineers, Ontario; the American Geophysical Union; the Canadian Association of Physicists; the Geological Society of America; the American Institute of Mining, Metallurgical and Petroleum Engineers; the Canadian Institute of Mining and Metallurgy, and the American Association for the Advancement of Science. He was elected a Fellow of the Royal Society of Canada in 1964 and a Fellow of the Geological Society of America in 1967. In May, 1967 he was granted the honorary degree of Doctor of Science by Queen's University. Dr. Uffen has represented Canada as a delegate at the International Union of Geodesy and Geophysics during meetings held in Rome, Toronto, Helsinki and Tokyo and was Chief Delegate for Canada, Switzerland, 1967. He was a Canadian delegate to the International Union of Geologic Science in New Delhi, 1964. Dr. Uffen has acted also as a consultant to exploration and construction companies as well as for the Stanford Research Institute on problems of the detection of nuclear explosions. In January, 1966 he became a member of the newly-established Council of Regents which advises the Ontario Government on the setting up of new Colleges of Applied Arts and Technology. He is on the Editorial Boards of two scientific journals: Tectonophysics, and Earth and Planetary Science Letters. In April, 1963, Dr. Uffen was named a Member of both the Defence Research Board and the National Research Council, and on 1 August, 1966 assumed the full-time appointment of Vice Chairman, Defence Research Board. Effective 3 March, 1967 he became CHAIRMAN, DEFENCE RESEARCH BOARD and simultaneously a Member of Defence Council. Dr. Uffen was married to the former Mary Ruth Paterson of Toronto in 1949 and has two children (Joanne and Robert). He was a mem-

ber of a small exploration team which discovered titanium ore in northern Quebec near a small body of water which was later named Lac Uffen. Dr. Uffen is an amateur painter. He is a member of the Rideau Club, Ottawa.

L'Heureux, Dr. Léon Joseph, B.A., B.Sc., M.E., D.Eng., Sigma XI. Dr. L. J. L'Heureux was born in 1919 in Gravelbourg, Sask. He received his primary education there, attended the College Mathieu, and received his Bachelor of Arts from the University of Ottawa in 1940. From 1940 to 1944 he studied at the University of Saskatchewan and obtained a Bachelor of Engineering in Physics. In 1944 Dr. L'Heureux joined the Royal Canadian Corps of Signals and served in Kingston, Brockville and Ottawa. During his posting in Ottawa he was responsible for technical aspects of the Army north west radio communication system. He obtained his release from the Canadian Army in 1947 to join the newly formed Defence Research Board. In 1946 Dr. L'Heureux married Yvette McKenzie in Ottawa and they now have seven sons and one daughter. From 1946 to 1949 Dr. L'Heureux attended the John Hopkins University in Baltimore, Md., where in 1948 he received his Master's Degree in Electrical Engineering and in 1949 he was awarded the degree of Doctor of Engineering and was made a member of the Sigma XI. In July 1949 Dr. L'Heureux was posted to the Canadian Armament Research and Development Establishment (CARDE) where he occupied a number of posts. From 1949-to-1952 he was Assistant Project Engineer on the Velvet Glove Guided Missile Project. In 1953 he was promoted to Director of the newly formed Guided Missile Division and in 1955 was appointed Deputy Director-General. In 1960-61 he attended the National Defence College and in 1961 was appointed Scientific Adviser to the Chief of the General Staff, Canadian Army. In 1963 Dr. L'Heureux was transferred back to CARDE to take up the position of Director-General, which he held until 3 March, 1967 when he assumed his present appointment of Vice-Chairman, Defence Research Board. Dr. L'Heureux has been active in a number of fields, Clubs, etc. His primary form of relaxation has been in sports. While attending college he pitched professional baseball in the South Saskatchewan league to pay for his education. In recent years he has devoted much of his time to the promotion of science. He is presently President of "*l'Association Canadienne Française pour l'Avancement des Sciences*". (ACFAS).

Houlding, John Draper, B.A. Born: 26 November 1921, London, Ontario. Married: Margaret Gordon Thompson 1945—3 children Anne, 1946, David, 1950, John, 1962. Education: Leamington High School, Ridley College, London South Collegiate BA, University of Western Ontario 1943 (Hon. Physics & Chemistry). Military Service: Royal Navy (on loan from Canadian Navy) 1943-1945 Lieutenant (L). Society Memberships 1. Past-President, Electronics Industries Association of Canada 1962. 2. Vice-President, Metropolitan Board of Directors, YMCA 1967-1968. Employment: 1. Engineering Dept. Canadian Westinghouse Co. 1945. 2. Sales Manager Electronics Divisions, Cdn. West. Co. 1950-51. 3. (On loan) Department of Defence Production 1951-1952. 4. Division Manager, Electronics Division, Atomic Energy Division 1951-1957. 5. Vice-President, Technical Products, RCA Victor Co. Ltd. 1957. 6. Director, RCA

Victor Co. Ltd. 1958. 7. Vice-President and General Manager, RCA Victor Co. Ltd. 1958. 8. President, RCA Victor Co. Ltd. 1960. Clubs: Rideau Club Ottawa, Royal Montreal Golf Club, St. James Club, Royal St. Lawrence Yacht Club.

Waldock, Major-General Donald Albert George, C.D.: Major-General D. A. G. Waldock was born in Ramsgate, England, on August 30, 1915, and attended the University of London where he graduated in science and electrical engineering. Prior to the war he was an installation and maintenance engineer with the British Broadcasting Corporation. General Waldock enlisted in the Royal Corps of Signals in 1939, was commissioned in 1940, and attained the rank of lieutenant-colonel in 1945. His service included tours with the British War office and with the British Army staff in Washington, D.C. General Waldock joined the Royal Canadian Artillery in 1946 as a major. In October of that year he became a technical staff officer in the Directorate of Armament Development for four years. He then attended the Royal Military College of Science in Britain after which he became Deputy Director of Armament Development at Army Headquarters in Ottawa. In August, 1952, General Waldock was appointed Commanding Officer of the Canadian Armament Design and Experimental Establishment at Valcartier, Quebec, with the additional appointment of Deputy Director-General, Canadian Armament Research and Development Establishment (CARDE). Early in 1955 he was named Director of Armament Development at Army Headquarters. In November, 1955, he was seconded to the Defence Research Board as Director-General, CARDE. On May 15, 1959, he returned to duty in the joint staff branch at National Defence Headquarters, serving as Director of Strategic Studies. In 1961 he was appointed Deputy Quartermaster General (Equipment Engineering) and after integration of the forces in 1964, became Director-General Engineering (Land). In July, 1966, General Waldock was appointed Deputy Chief Engineering in the Technical Services Branch at Canadian Forces Headquarters.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, October 24, 1968.

The Special Committee on Science Policy met this day at 10.00 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, first of all this morning, for the purpose of the record, I would like to say that after the committee adjourned its public hearing yesterday afternoon, we were of the opinion that we needed additional information from the National Research Council. It was decided that on behalf of the Committee I would write a letter to the President of the National Research Council, asking for this additional information, and that we would meet again with the Council at a later date when this information is available.

This morning we have the pleasure of having with us the Chairman of the Defence Research Board, Dr. R. J. Uffen, and his colleagues Dr. L. J. L'Heureux, Vice-Chairman, on my left; Mr. J. D. Houlding, on my far right, President of R.C.A. Victor, and on my far left, Major-General D. A. G. Waldock, who presumably will be the main speaker this afternoon, when we hear the brief which has been prepared by the Department of National Defence on the Armed Forces research activities.

You already have the biographies of these gentlemen, so I will certainly not take time in recalling what they have done in life; it is public knowledge.

So, without any additional comment, I would ask Dr. Uffen to begin his representation.

Dr. R. J. Uffen, Chairman, Defence Research Board: Thank you very much.

Mr. Chairman, honourable senators:

1. It is a pleasure to address you today on the subject of science and its relation to the activities of the Department of National Defence of Canada.

2. My position as Chairman of the Defence Research Board makes it appropriate for me to be its spokesman and, at the request of the Deputy Minister, I have undertaken to submit this brief in collaboration with the Canadian Armed Forces. Within the Department of National Defence there are two main agencies that are concerned with scientific research and development. These are the Defence Research Board and the Chief of Technical Services Branch of the Armed Forces.

3. Because of the complexities of identifying the various aspects of research and development in these two large organizations, one primarily civilian and the other primarily military, we have submitted the information required by your "Guidelines for Submission of Briefs and Participation in Hearings—Specific Guidance for Agencies of the Federal Government" in two parts: Part I Defence Research Board Activities and Part II Armed Forces Activities.

4. Our Department is a large one and I, myself, have been directly associated with it for only two years. I am aware that there are aspects of the DND's scientific history which will interest you and are best explained by those who have had a longer association with defence than I.

5. May I begin by introducing my colleagues who will assist in making this presentation and in answering your questions:

(a) Dr. L. J. L'Heureux, Vice-Chairman, DRB with more than twenty years' experience in all aspects of defence research.

(b) Mr. John Houlding, President of RCA Victor and Chairman of the Selection Committee of DRB.

(c) Maj-Gen. D.A.G. Waldock, Deputy Chief of Technical Services for Engineering of the Canadian Armed Forces and long associated with defence research and development.

6. With your permission, I propose to speak for approximately thirty minutes followed by Dr. L'Heureux for about fifteen minutes, then I will summarize. I understand you would like to then have a question period before proceeding with a presentation by General Waldock this afternoon on the Armed Forces Activities.

Evolution of Organizational Policies and Principles

7. Immediately following the cessation of the II World War in 1945, consideration was given to the problems of organizing Government scientific research in peacetime. In 1939 the National Research Council had one laboratory and a staff of 300; by the end of the war it had nearly 2,000 employees working in 21 laboratories, engaged almost entirely in military research.

8. The President of the National Research Council then, Dr. C. J. Mackenzie, stated that in his view both civilian and military research were major fields in themselves and that each required the full attention of a directing staff. He felt that if NRC took on the additional responsibility for military research either the civilian or military aspect of its work would be neglected. He also pointed out that in matters of military research user knowledge was important and could only come from the Forces themselves. He urged that the NRC should *not* be asked to continue to carry out military research.

9. Agreement was reached in 1946 that defence research should be the function of an agency within the Department of National Defence and that the effort should be closely related to the scientific work of a similar nature being done in Britain and the United States. The Defence Research Board came into being in 1947 and took over direction of the majority of military research establishments being operated by the Navy, Army and Air Force.

Statutory Functions of DRB

10. The statutory functions and powers of the Defence Research Board are contained in Part III of the National Defence Act as amended to 1967, which is reproduced at Appendix A of Annex II.

11. Briefly, the functions of the Board are "to carry out such duties in connection with research relating to the defence of Canada and development of or improvements in material as the Minister of National Defence may assign to it, and to advise him on all matters relating to scientific, technical and other research and development that in its opinion may affect national defence".

12. The Board consists of a Chairman and a Vice-Chairman, certain ex officio members, and several additional members representative of universities, industry and other research interests as the Governor in Council appoints.

13. The current membership is as follows:

Chairman — Dr. R. J. Uffen

Vice-Chairman — Dr. L. J. L'Heureux

Ex officio members — Dr. W. G. Schneider, —whom you met yesterday—President of the National Research Council

— Mr. E. B. Armstrong, Deputy Minister of National Defence

— Gen. J. V. Allard, Chief of the Defence Staff

— Lt-Gen. F. R. Sharp, Vice-Chief of the Defence Staff

— Lt-Gen. L. G. C. Lilley, Chief of Technical Services.

Members by Appointment

Dr. W. G. Bigelow—Associate Professor of Surgery, University of Toronto and Senior Surgeon, Division of Cardiovascular Surgery, Toronto General Hospital.

Dr. H. E. Duckworth—Vice President (Academic), University of Manitoba—a physicist.

Mr. J. D. Houlding—President and Director, RCA Victor Co. Ltd.

Mr. G. W. Hunter—Deputy Minister of Defence Production.

Dr. H. H. Kerr—Chairman, Ontario Council of Regents for Colleges of Applied Arts and Technology.

Dr. A. B. Van Cleave—Chairman, Division of Natural Science, University of Saskatchewan.

Prof. Maurice L'Abbé—Vice Rector, University of Montreal.

Prof. Napoléon LeBlanc—Vice Rector, Laval University.

14. I do not propose at this time to elaborate on the duties of the various officers of DRB as they are given in Annex I, page II of the brief. Nor do I propose to go over all the organization charts of our research establish-

ments. However, I would like to give you a brief description of their main activities and those of our Headquarters. For this purpose the chart entitled: Defence Research Board Organization, Appendix II of Annex I (page 11) may be useful. The Defence Research Board at present has 2700 employees of which approximately 600 are professionals, i.e. graduates of universities or their equivalent. The Board has a total budget for 1968-69 of $50.8 Million (see Annex VI for details), and operates eight separate research establishments distributed across the country, and a headquarters.

15. The Defence Research Establishment Atlantic (Appendix E)

The Defence Research Establishment Atlantic (DREA) Dartmouth, N.S. is concerned primarily with research related to problems of anti-submarine defence in the North Atlantic including underwater acoustics, signal processing, and transducer research and hydrodynamics. In addition, DREA provides certain dockyard laboratory services for the Canadian Maritime Forces.

16. The Canadian Armament Research and Development Establishment (Appendix F)

The Canadian Armament Research and Development Establishment (CARDE) Valcartier, P.Q. is concerned with research in the fields of armament, night vision aids and detection devices, propellants and explosives, aerospace research and weapons systems analysis. Its role involves close links with the Canadian Armed Forces, and a substantial number of Service personnel are attached to the Establishment. Its working language is French.

17. The Defence Research Analysis Establishment (Appendix G)

The Defence Research Analysis Establishment (DRAE), here in Ottawa, of the Defence Research Board is also a division of Canadian Forces Headquarters and is staffed by both Defence Research Board scientists and by military officers. Operational research scientists, working under the general supervision of DRAE, are also located at the headquarters of some of our Canadian Forces Commands elsewhere.

The work of DRAE includes the analysis of strategic problems, investigations of maritime, land, and tactical air operations and equipment, analytical studies of North American defence questions, and studies of problems concerning the deployment and utilization of military personnel, programming, and logistics. In addition, DRAE plays an active role in the planning and analysis of various exercises and field trials, and provides certain statistical and mathematical services for the Canadian Forces.

18. The Defence Chemical, Biological and Radiation Establishment (Appendix H)

Activities at the Defence Chemical, Biological and Radiation Establishment (DCBRE), Shirley Bay, Ontario—which is on the outskirts of Ottawa—consist of research into the defensive aspects of biological, chemical and nuclear warfare, and investigation of electrical power sources (which include batteries, fuel cells, thermionic and thermoelectric devices but not conventional electrical generating systems).

19. The Defence Research Telecommunications Establishment (Appendix I)

The Defence Research Telecommunications Establishment (DRTE) Shirley Bay, Ontario is concerned primarily with applied research in radio wave propagation, military communications and radar systems, and signal detection. In the field of electronics, applied research and instrumentation are combined with fundamental investigations into solid-state physics, and with studies of electronic circuits. Radio physics studies deal mainly with the physical processes in the upper atmosphere that affect radio propagation and radar. The Defence Research Board's satellite program has been a special feature of DRTE's activities in recent years. DRTE is in the process of being transferred to the proposed new Department of Communications.

20. The Defence Research Establishment Toronto (Appendix J)

The research program of the Defence Research Establishment Toronto (DRET), at Downsview, Ontario is concerned with the factors involved in the efficient performance of Servicemen in various adverse military environments. Broadly speaking, the role of DRET is to measure and understand the particular capabilities and limitations of human beings which are of special significance to the military, and to promote recognition of these variables in the design of military equipment

and the formulation of training and operational procedures.

21. The Defence Research Establishment Suffield (Appendix K)

Defence Research Establishment Suffield (DRES) at Ralston, Alberta, which is 30 miles north of Medicine Hat, consists of a central laboratory together with a secure test area of approximately 1,000 square miles with access roads, communications systems, power supplies, an airport and a village, The establishment conducts basic and applied research on problems concerned with defence against biological, chemical, and nuclear warfare. The programs of DCBRE at Shirley Bay and DRES at Ralston are complementary and closely coordinated.

22. The Defence Research Establishment Pacific (Appendix L)

The Defence Research Establishment Pacific (DREP) Esquimalt, B.C. is primarily engaged in research leading to improved methods for the detection of submerged submarines with special reference to Pacific Ocean conditions. The effort is mainly distributed among three fields of physical research—underwater acoustics, low-frequency electromagnetics, and fluid dynamics. It also provides scientific and engineering consultative services and assistance to the Maritime Forces on the Pacific coast.

Formal Agreements with Foreign Agencies

23. The Defence Research Board is formally involved with foreign countries and foreign defence science agencies as the designated representatives of the DND in some cases and as a signatory in others.

(a)—North Atlantic Treaty Organization (NATO): DRB supports the NATO Defence Research Group and its panels, the Supreme Headquarters Allied Powers Europe (SHAPE) Technical Centre, the Supreme Allied Commander Atlantic (SACLANT) Anti-Submarine Warfare Research Centre and the Advisory Group for Aerospace Research and Development (AGARD).

(b)—Bipartite Agreements with NATO Nations: DRB also has bipartite agreements for the exchange of defence science information with Norway, the Netherlands, West Germany, Greece, France and Denmark.

(c)—The Technical Cooperation Program (TTCP): This program is based upon an agreement between Canada, the United States, Australia and the U.K. to collaborate in defence science with the aim of improving their combined efficiency of these four countries and minimizing duplication of effort. It is probably our most important international program at present.

(d)—The Defence Research Board/Royal Canadian Air Force/United States Air Force (DRB/RCAF/USAF) Agreement: This agreement, signed December 1958, facilitates the exchange of defence science information with the USAF.

(e)—The Commonwealth Defence Science Organization (CDSO). This Organization, which was established shortly after World War II, is the basis for the exchange of defence science information between the countries of the Commonwealth.

(f)—The Canadian Armament Research and Development Establishment/Advanced Research Projects Agency (CARDE/ARPA) Agreement: This agreement covers the collaboration between CARDE in Quebec, of DRB and ARPA of the U.S. Department of Defence on that part of CARDE's program which is related to defence against ballistic missile attack of North America.

(g)—The Defence Research Board/National Aeronautics and Space Administration (DRB/NASA) Agreement: This agreement covers the collaboration between the Defence Research Telecommunications Establishment (DRTE) and NASA of the U.S. for launching and subsequent operation of the Alouette and ISIS satellites (International Satellites for Ionospheric Studies).

(h)—Initial Defence Communications Satellite Project (IDCSP). This agreement covers collaboration between DRTE and the United States Army under which DRTE is permitted to make use of US military communications research satellites in conjunction with Canadian developed ground equipment for research purposes.

By means of these agreements Canada is able to augment its own research in a major way.

Offices in other Countries

24. Since its inception, the Defence Research Board has maintained liaison offices in the United Kingdom (London) and the U.S.A. (Washington, D.C.). In 1965 the post of Defence Research Attaché was created on the staff of the Canadian Ambassador to France.

Organizational Functions and Policies

25. I would like now to speak about our organizational policies, first of all in relation to the Armed Forces. From the scientist's point of view, defence has provided tremendous incentives backed by large sums of money. Without the requirements of the military it seems certain that many of the most important technical achievements of the last twenty years would not yet have been made, or would have been delayed. Defence is also, however, a very difficult taskmaster and those who work for defence departments must face changes in requirement and contro-tions in policy which are not easy for the laboratory trained scientist to accept.

26. Important problems of national defence are increasingly of a scientific and technical nature. Technological training and experience have become increasingly important for Armed Forces personnel, particularly for those who have responsibility for planning and carrying out the development or purchases of new equipment. Although the Defence Research Board has the nucleus of scientists within the Department, it by no means contains all the technological talent of the Department. The Armed Forces have many technologically trained officers and civilians in their complement and they make many technical decisions.

27. Prior to integration, each Service maintained technical branches headed by a senior officer and interconnected by a complex committee structure. There was, from a purely scientific point of view, considerable overlap between the three Services, but this was usually justified on the basis that the final requirements in terms of equipment differed from Service to Service.

28. The division of responsibilities between the Defence Research Board on the one hand and the Armed Forces technical branches on the other was never very sharply defined. Broadly speaking, the Defence Research Board was responsible for basic and applied research, the Armed Forces technical branches for the development of equipment, and the Department of Defence Production for the production of the finished article. There have been, however, many variations of this arrangement, and Major General Waldock will deal with this subject at greater length this afternoon.

29. The Board also recognizes a number of principles which are applicable whenever decisions are made on the nature, scope and magnitude of its research programs whether carried out within the Board's establishments or extramurally in universities and industry. The first of these is that its advisory and supporting role to the Minister and the Forces is its primary and major responsibility; contributing to the collective efforts of our allies in defence research comes second; and the support of university and industrial research related to defence comes third. However, another important principle is that a proper balance between long-term and short-term programs must be maintained. It is important that the DRB foresee future scientific and technological development by keeping Canadian defence science in the forefront of advances to new knowledge. Its attention must therefore not be concentrated entirely on current problems, or even on the clearly apparent problems of the immediate future.

30. In 1967 policy concerning the operations of the Board was critically and thoroughly reviewed. The outcome was the adoption of a policy of decentralization by which the responsibilities for program implementation were transferred from headquarters in Ottawa to the establishments, while retaining the responsibilities for planning and personnel and financial management in headquarters.

31. These changes were made to accomplish several purposes. One was to develop closer links between DRB and the Services at both the "management" level and the working scientist level. Two benefits are expected: our scientific support to the Services is being strengthened, and conversely the needs of the Services are becoming better known at all levels within DRB, particularly in the laboratories where ideas are generated. In other words, we want our scientists to be

familiar with military problems, attitudes and thinking so that they will be defence scientists rather than just scientists in a defence establishment. A second purpose was to free headquarters from the concerns of daily operations in order to concentrate on policy and planning. A third purpose was to ensure strong scientific and technological links from establishments to universities and to industry. Finally, it will provide better career opportunities for our scientists and make more effective use of available resources.

32. The importance which we attach to close relationship between the DRB and the Armed Forces is emphasized by the appointments of senior DRB scientists as scientific assistants to both the Vice Chief of the Defence Staff and the Chief of Technical Services. These two scientists have very important responsibilities in ensuring that the scientific and technical interests of the Armed Forces are made known to DRB and, conversely, bringing to the attention of the Armed Forces the assistance and advice which science can give. We are in the process of establishing a third scientific assistant to the Chief of Personnel, who will be concerned with human problems.

33. Of particular interest is the arrangement for handling operational research and systems analysis. I would like to dwell on this subject for a few moments since I feel that it has special importance. The science of operational research grew very rapidly during scientists were used to analyze the operation- World War II when for the first time trained al effectiveness of military forces in the field and to devise new strategies and techniques which would improve their capabilities. Since World War II the complexities and expense of military equipment have made it necessary to carry out very detailed and careful analysis before such systems are developed and constructed. The type of training needed for operational research and for systems analysis is similar. Both require a strong mathematical and analytical background, an inter-disciplinary approach all backed up by military experience.

34. Within the Department of National Defence we have an excellent arrangement whereby scientists and military officers combine to provide these services. The point I would like to make here is that we now need highly qualified scientists in the development of long-term strategy. In such areas as personnel selection and training, the demand for social scientists is increasing and the DRB is now concerned with research fields in which it has hitherto not been involved.

35. As Chairman of the DRB I am a member of Defence Council, the senior decision-making body of the Department and can arrange for a scientific input to matters which are dealt with by this Council. The Chief of the Defence Staff holds regular meetings to discuss planning or operations of the Armed Forces and the Vice-Chairman, DRB or myself attend these meetings. The development of equipment for the Armed Forces is the responsibility of the Chief of Technical Services. He receives guidance from a senior group, the Development and Associated Research Policy Group (DARPG). The DRB member of this group is my Deputy Chairman (Scientific). DRB is thus able to arrange that certain development projects be undertaken in its establishments and to assist the CTS with both the technical aspects and management of those projects carried out by Canadian industry.

Organizational Functions and Policies in Relation to Other Federal Agencies

36. DRB has certain responsibilities vis-a-vis other organizations of which the most important are the NRC, the DOI, the DDP, the DEMR, and the DOT. These are outlined in Annex II, pages 4, 5 and 6, so I will not dwell on them now. You may perhaps be more interested in our relations with industry and with universities. I shall be referring to industrial research contracts and also to grants for industrial research. In the former case we get done what we want done: in the latter case we support what they want to do.

Organizational Functions and Policies in Relation to Industry

37. The Board's policy with respect to industry is one of collaboration and assistance whenever possible. Liaison with industry is maintained at all levels from the Board itself down to the scientists at the laboratory bench. The Board's esabtlishments undertake part of their work by means of research contracts with industrial research laboratories. In the period 1962/63 to 1967/68 DRB has spent

$20.4 millions on research contracts with industrial firms. This does not include the Electronic Components Research and Development program, administered by DRB, and funded jointly by DRB and the Canadian Forces which has involved the spending of $11.5 million on research and development contracts in the same period.

38. The following table of expenditures for research in support of intramural programs gives the dollar value of the contracts in industry, universities and other Government agencies—

	Industry	Universities	Gov't Agencies
1963-64 ..	1,200,000	400,000	160,000
1964-65 ..	3,371,000	447,000	168,000
1965-66 ..	3,994,000	368,000	180,000
1966-67 ..	4,993,000	417,000	180,000
1967-68 ..	4,238,000	642,000	198,000

You can see it has increased by a factor of 4 in industry since 1963.

39. Defence Industrial Research Program. I would like to emphasize the distinction we make between contracts and grants. Grants are awarded to promote and strengthen the research capability of Canadian industry in defence technologies. Assistance is available through the D.I.R. to enable firms to establish new research programs or to expand existing research activities. The goal is to improve both the quality and quantity of applied research in Canadian defence industry so as to enhance its ability to meet the needs of the Canadian Armed Forces competitively and to participate in the development and supplying of equipment with our allies.

40. Projects submitted to DRB for appraisal are initiated by Canadian companies and are not necessarily related to the DRB intramural program.

41. The Advisory Committee on Defence Industrial Research (ACDIR) which examines and makes recommendations regarding such company proposals, is an interdepartmental committee composed of representatives from the Defence Research Board, National Research Council, Department of Industry, and Department of Energy, Mines and Resources. Once the research stage is completed, it is possible to advance a program into the development stage through various assistance programs of the Department of Industry. Proposals having minimal defence interest can be referred to the National Research Council for consideration under their Industrial Research Assistance Program. By this means, duplication of support of research programs in similar fields of endeavour by separate Federal agencies is avoided. Details of the D.I.R. program are given in Appendix B of Annex VII and in Table II of Annex IX.

Organizational Functions and Policy in Relation to Universities

42. Let me now refer briefly to the University Grants Program. The awarding of grants to members of university staffs has three objectives. The first is to acquire new scientific knowledge that may prove applicable to the solution of defence problems; the second is to develop and support in the scientific community as a whole, an interest in defence science that will be valuable in the long run; the third is to assist in staffing the various establishments of the Board with promising young scientists. The main criteria used in judging grant applications are the scientific quality of the proposed work and its relevance to defence interests; it need not be related to the intramural program of the Board.

43. The details of how grant applications are processed are given in Appendix A of Annex VII and the lists of projects and expenditures are given in Table I of Annex IX. There are no secret projects carried out in universities under our University Grants Program.

Personnel Policies

44. I do not propose to elaborate on our personnel policies except to draw your attention to the fact that since its inception the Defence Research Board has been independent of the Civil Service Commission (now the Public Service Commission) and has developed its own personnel policies suited to the needs of a research organization. More recently the Board was given separate employer status under the Public Service Staff Relations Act 1967. In practical terms the DRB has the same responsibilities for employment and staffing as the Public Service Commission, the responsibilities for personnel administration exercised by the Treasury Board for the Public Service generally, and for the appropriate machinery for collective bargaining. The DRB exercises the responsi-

bility for collective bargaining through the activities of two committees—the Bargaining Policy Committee and the Bargaining Committee in consultation with the Treasury Board staff.

45. Mr. Houlding is available to answer your questions concerning the Selection Committee of DRB which exercises the responsibility for approving applications for employment and recommendations for promotion.

46. DRB has been able to attract first-class scientists and engineers because of first-class working conditions, personnel policies and equipment, and exciting projects in the forefront of scientific research. Of the professional staff, 34 per cent have Masters degrees and 26 per cent have Doctorates. Twenty-four per cent have had industrial experience; 26 per cent received part of their education abroad, and 16 per cent are in primarily executive or administrative positions. Approximately 22 per cent are effective in both our official languages. The turn-over rate is average, approximately 8 per cent per year, and the "average professional" has been with DRB for 13 years and is 44 years of age. I would like to draw your attention to an error I made in the submission, Part I, page ix, line 5. I will have the correction made. It says 5 per cent but it is actually 8 per cent or close to it.

47. The average age of 44 years is high for a research organization and there is a tendency for the staff to become concerned with the problems of maturity, i.e., concern for job security, promotion, status and pension plans. Under present restrictions this average age is likely to increase which is an unhealthy trend for a research organization. There are a limited number of senior executive positions and older men who fail to occupy such positions sometimes become discouraged. It is unlikely that a Canadian scientist under 40 years of age will have had military experience, so there is a probability that problems of national defence will be unknown to or disregarded by the oncoming generation of young scientists unless they spend a part of their career in a defence research establishment.

48. I would now like to ask Dr. L'Heureux to tell you something about the distribution of our activities regionally; how DRB relates its programs to the needs of our users—the Canadian Armed Forces, and perhaps a little more about the nature of our intramural programs.

[*Translation*]

Dr. L. J. L'Heureux (Vice-Chairman, Defence Research Board): Mr. Chairman, Honourable Senators:

49. Our Chairman's brief which you have just heard touched only briefly on three of the important aspects or functions of our organization, namely the relation of the research projects to military operations, the research programme itself and, finally, the geographical distribution of our activities.

50. First, let us consider the relation of the research projects to military operations. The purpose of the Board, as its name implies, lies mainly in its capacity to answer within the limits of its resources what could be called the operational imperatives of the Armed Forces of Canada. What are these operational imperatives? They can be expressed, I believe, very clearly in the five following functions necessary to any military force:

(a) active combat and defence,

(b) civil defence,

(c) command and control,

(d) logistics,

(e) personnel.

51. From these five basic functions, it is easy to enumerate for each one the following secondary activities involved:

—for active combat and defence, fire power and tactical mobility,

—for civil defence, defence works, concealment and deceit, as well as obstacles,

—for command and control, observation, scouting, navigation, communications and data processing,

—for logistics, distribution, movement, maintenance and repair of equipment, movement of personnel and auxiliary medical personnel, protection against the environment, prevention and limitation of damages,

—finally, for personnel, how to use it, direct it and assess its human performance.

52. To each of these activities, obviously, are associated either equipment needs (arms, vehicles, mines, explosives, etc.), or offensive

or defensive elements (vulnerability, the art of camouflage, tactics), which require scientific research. It is also obvious, if you consult the detailed table, that the scientific research necessary to carry out operational imperatives involves a great many subjects. A summary of these subjects is given in Appendix IX of our report which contains a list of the research projects supported by the Board in its own laboratories or in universities and industry.

53. Now that the necessity of scientific research for defence is established, let us consider how our organization performs its task of supplying this requirement, which is why it exists. Our activities are concentrated into three main programmes, i.e. the internal programme of the Board involving activities in the eight laboratories it operates, and the respective programmes of research subsidies to university or industry.

54. The priority established for research projects depends, in the first place, on the immediate and actual needs of the armed forces, needs which will vary according to the precise role assigned to these armed forces in our present world. In addition, the work projected must always reflect the criterion of scientific excellence.

55. However, as Canada is not a superpower, resources allocated to scientific research are limited. Therefore, we will not undertake any major project. We must also add that the selection of certain projects is influenced by the agreements signed by Canada in the field of defence with its allies, eepecially the United States, England and the NATO countries. These projects, however, have a Canadian accent in the sense that they concern an aspect of research which is particularly useful to our country. Sometimes, certain projects are carried out here because our country, either because of its geographical location, or because of the very high skills at its disposal, is in a better position to put them into effect. Finally these projects, useful to our allies, open the door to a reciprocal exchange of information with the countries concerned, an exchange which can only help our own projects.

56. Moreover, this method of relating specific projects to operational imperatives is presently at the experimental stage; when its structure is completed, it will then become possible to evaluate quantitatively as well as qualitatively the respective value of the research projects which are all aimed at the improvement and the maintenance of the operational capacity of the Canadian Forces. This method also shows implicitly that technology constitutes an essential link between scientific research and military operations.

[*Text*]

Projects

57. Up to this point, I have discussed the criteria which influence the Board's decisions in planning its activities whether intramural or extramural. It is now appropriate to describe the research program briefly. A detailed list of the projects associated with the intramural, university and industrial programs is presented in Annex IX of the DRB report to the Committee.

58. I will not attempt here to go into a detailed review of these projects. I will only consider the relative size of the various programs funded by the Defence Research Board. The following schematic shows the distribution of funds for 1967-1968.

Gentlemen, you have this schematic in front of you.

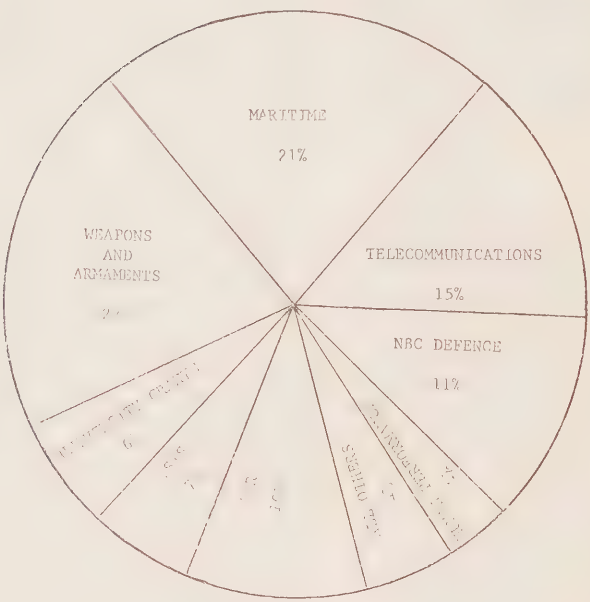
(*See page 278—Table 1*)

59. over 70% of these funds are spent intramurally in fields of particular importance to the military, namely, weapons and armaments, maritime research, telecommunications and nuclear, biological and chemical defence. The intramural program is carried out in the eight establishments operated by the Board. The table also shows that a far from negligeable part of the funds—over 25 per cent—goes to our extramural programs of research grants and contracts to universities and industry. In terms of funds committed to these two programs, the amounts for 1967-1968 are 2.9 millions for the university grants program and 4.5 millions for the industrial research program.

You will note also 7 per cent which is three and a half million for the satellite program. These two programs differ in their immediate objectives in that the university grants program is concerned primarily with basic research while the industrial program leans more toward applied or hardware oriented research. The method of funding these programs reflects this situation: the research projects given to universities are entirely

D-10

TABLE I: Relative Size of Programs 1967-1968



(E follows)

funded by the board while the research grants to industry only covers part of the cost involved as some of the end products of this research may bring some commercial benefit to the company concerned.

60. As I have already related the Board's activities to the operational requirements of the armed forces, it is appropriate here to consider the allocation of the Board's financial and human resources between the five military functions I mentioned previously. Table 2 gives these figures for 1967-1968.

TABLE 2

	Funds (millions)	Strength (Staffing)
Combat and Active Defence	7.3	539
Passive Defence	0.937	89
Command and Control	14.429	1029
Logistics	1.534	116
Manpower	2.077	181

[*Translation*]

61. I now want to deal with the geographical distribution of our activities, especially with regard to the money we are spending in the various areas of the country. As you already know, the Council operates eight laboratories located geographically as follows:

—Defence Research Centre—Pacific,

—Defence Research Centre—Suffield, in Alberta

—Defence Research Centre—Toronto,

—Defence Chemical, Biological and Radiation Centre—Ottawa,

—Defence Research Telecommunications Centre—Ottawa,

—Defence Analysis Centre—Ottawa,

—Canadian Armament Research and Development Centre—Valcartier, near Quebec City,

—Defence Research Centre—Atlantic.

62. If we consider the geographical distribution under the heading of money spent annually in each region, we must add to the amounts allocated to internal expenses the money used to pay the costs of the programmes of grants and contracts to universities and industry.

63. The table attached to my brief shows the amounts spent by the Board in each province of Canada for the fiscal years 1963-1964 to 1967-1968 inclusive.

You see, in the table, gentlemen, the breakdown of expenses, by regions, in thousands of dollars, from the year 1963 to the year 1968, and the expenses in our laboratories, in industry and in universities. Each province is represented, except Prince Edward Island.

The distribution in each province and in the three programmes considered can seem very uneven. This unevenness is explained, however, if we consider the three programmes of the Board in relation to the criteria governing the selection of the projects, that is the scientific excellence of the idea and its contribution to fill an existing need of the armed forces. The disparity shown by the table is then justifiable in the sence that certain regions, stronger economically, have a greater number of more important companies or universities which consequently operate research facilities that do not exist in the less favoured regions of Canada. However, the Board observes constantly all the Canadian research organizations—universities, companies or government—in order to identify the human skills or the research facilities which could contribute to the carrying out of its duties.

If we consider the table in detail, a few explanations are needed. The provinces of Saskatchewan and Manitoba have received funds allocated to internal research during certain years. This is explained by the fact that the Board operated laboratories in these provinces until very recently. More precisely, the Board operated until 1967 the radar laboratory in Prince Albert, still the Board's responsibility, but whose activities are presently suspended. Similarly, the station at Churchill, Manitoba, operated and financed by the Defence Research Board until 1966, is now under the jurisdiction of the National Research Council. Finally, it could seem to you that Ontario, on the whole, appears more favoured than the other provinces of Canada. This is explained in part by the fact that the headquarters of the Board are located in this province and that they control funds shown in the table, which however are spent in other provinces of Canada. I mention, as an example, funds allocated to construction, which are obviously spent in the province concerned, but which are supplied directly by the headquarters of the Board.

DISTRIBUTION OF EXPENSES BY REGION

$'000

—	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	Nfld.	Total
1963–64—Internal	1,051	3,152	443	262	13,430	7,778		2,192		
Industry	36	100		—	1,698	1,533		25		
University	189	90	126	64	892	458	7	67		
Total	1,276	3,342	569	326	16,020	9,769	7	2,284		33,593
1964–65—Internal	1,079	3,219	303	222	13,947	7,708		2,027		
Industry		114		21	2,666	3,593		21		
University	177	72	87	68	835	530	20	73		
Total	1,256	3,405	390	311	17,448	10,831	20	2,121		35,782
1965–66—Internal	1,253	3,751	379	55	14,945	8,463		2,447		
Industry	34	417		7	3,540	4,269		16		
University	205	71	115	49	949	555	24	87		
Total	1,492	4,239	494	111	19,434	13,287	24	2,550		41,631
1966–67—Internal	1,540	4,142	395		14,751	9,306		2,582		
Industry		544		4	2,989	5,478		—		
University	277	77	121	63	1,170	608	38	104		
Total	1,817	4,763	516	67	18,910	15,392	38	2,686		44,189
1967–68—Internal	2,145	4,198	125		16,464	9,666		3,257		
Industry	318	415		1	2,764	4,803		—		
University	3,701	213	129	96	1,291	681	32	58	5	
Total	6,164	4,826	254	97	20,519	15,150	32	3,315	5	50,362
GRAND TOTAL	12,005	20,575	2,223	912	92,331	64,429	121	12,956	5	205,557

Mr. Chairman, Dr. Uffen will now continue with our brief.

[*Text*]

Dr. Uffen: Mr. Chairman, I would like to conclude with a brief summary.

(a) DRB has played a very large role in Canada's scientific activities. In the early days it was the major supporter of medical research. From 1962-67 DRB sponsored approximately 500 university projects costing $13,100,000. No secret work is sponsored under this University Grants Program.

(b) Because of the creation of new scientific agencies such as the Medical Research Council, the Science Council, the Science Secretariat, the Department of Industry, Atomic Energy of Canada, etc, and the rapid growth of civilian industrial research, the relative impact of DRB's activities is decreasing.

(c) DRB has played the leading role in research satellite development in Canada and has made it possible for Canada to undertake to develop its own civilian satellite communications system.

(d) Research projects sponsored by DRB has given rise to Canadian production orders close to $200,000,000, a large proportion of which has been export trade. From 1962-67 the Defence Industrial Research program sponsored 166 projects with DIR funding of $28,300,000 and equal amount from industry. Several new industrial operations have arisen from DRB's programs and support.

(e) DRB has just completed a reorganization. Through the introduction of program budgeting; emphasis on planning, operations research and analysis; and the creation of the posts of Scientific Assistants to the senior military officers, DRB is better able to adjust to the needs of the unified Canadian Armed Forces, and changing defence and foreign policies.

(f) The separation of the responsibility for research and preliminary development (DBR) from that for development (CTS Branch of the Armed Forces, and DOI) and procurement (DDP) presents some problems. This division of responsibility for defence R and D between four agencies in three Government departments has been unusual in the Western Alliance.

(g) The Chairman, DRB, advised by the members of the Defence Research Board and supported by the activities of the advisory panels and permanent staff of its headquarters, its research establishments and its liaison network, provides a necessary civilian scientific contribution to the deliberations of the Defence Council.

I would conclude with three recommendations:

(a) Increased salaries and soaring equipment costs within a fixed or declining budget would reduce the number and extent of projects. Sooner or later it will be necessary to either increase the funds available or close some research establishments. The local economic and social implications of staff lay-offs and laboratory closures must be anticipated. Consideration should be given to the possibility of "forced attrition" by introducing incentives for early retirement or transfers to other agencies.

(b) It would be desirable to improve the "portability" of pension plans with industry and universities.

(c) Sudden major changes in Government policy and funds should take into account the lead time required to make corresponding changes in research programs. No major changes in DRB's roles and abjectives are being planned but may arise, nevertheless, as a result of major changes in policies regarding science or defence.

The Chairman: Thank you very much. We will now adjourn for coffee, and come back in about 15 minutes.

(A short recess.)

Upon resuming.

The Chairman: Shall we proceed? Senator MacKenzie?

Senator MacKenzie: Mr. Chairman, Dr. Uffen and your colleagues: I have listened with a great deal of interest to the presentation you have made to us this morning, and I am much impressed by the variety and the extent of the importance of the work done by the Defence Research Board and its various branches and agencies.

Reading through some of the literature that was loaned me by members of our staff, particularly that relating to the reports of the Select Committee on Science and Technology in the United Kingdom, I was surprised at the amount of money spent in that country on research in this and other fields and at, in their view, apparently, the rather limited production resulting from it in terms of the output of marketable products and the like. This is back of my mind with respect to the first question I would like to ask.

We are allies of, and in special relationships with, the United States, Great Britain and other of the NATO countries, but in particular these two countries. We do know that both these countries are spending very large sums on military research development, weaponry and the like; whereas we do know that our possibilities in this field are not equal to, and should not and could not be equal to, those of the United States, in particular.

So, the first question I would like to ask is whether our research efforts are directed to specialized programs that are rather peculiar to Canada or in which Canada can make, because of its circumstances—its geography, its location—a special contribution.

Allied with that is the question of whether the research being done or to be done by the various nations, and particularly the two I have mentioned, is shared, as it were, in the sense that we might be responsible for research and development in certain rather limited fields, and Britain and certain others, and the United States and certain others, Germany, France, and so on, so we would get the maximum research rather than playing the field.

This is the first of the questions, and I would prefer it if they could be answered in sequence, if that is in order.

Dr. Uffen: We are a small nation. We have limited amounts of money. I think it is national policy not to get in a military-industrial complex of the type that has developed in the United States. Also, we have to be very selective in what we undertake, and we do try to do just what you suggested. That is, to work in areas which are peculiarly suitable by reason of geographic or other factors, which give us a natural head start as, for example, the study of the Aurora. As most of us know, it is centred over Northern Canada and not over the North Pole. This affects radio communications, radar and a number of things of crucial importance to Canada and to our allies, so for quite some time we have been active and quite good, we believe, and highly regarded by our allies in that particular area.

We have certain natural advantages in studying conditions in the Arctic—snow and ice problems—so we have a small but first-class group of people, highly respected, both in the civilian and military world, in glaciology.

We have certain peculiar facilities in some of our laboratories. At CARDE, at Valcartier, we have some hypersonic ranges which have not been duplicated elsewhere.

At Suffield, Ralston, we have approximately 1,000 square miles of land used for test and evaluation purposes, without danger to the public.

We undertake programs, in consultation with our allies, and if you will recall I mentioned the TTCP as being perhaps the most important one right now. That is Britain, the United States, Australia and Canada. There is a whole network of technical committees—I would guess, perhaps two dozen of them—which meet regularly. A Canadian might be chairman of one or other of them in which we have special competence; or if we do not possess special competence, we will have a member on these committees, and they generate the projects and recommend which country is the best one to undertake a specific one. When these are generated they go through a long process of evaluation before they actually get funded and implemented.

There is a real danger that we can spread ourselves too thin. However, I take the view that one of my unwritten responsibilities is that of being able to marshal the nation's scientific competence, if need be. This requires us to have one or two first class people in many areas of science and technology for purposes of advice and for an entrée to the real competence wherever it might be.

Senator MacKenzie: I was interested in a statement that is contained in the introductory section of your brief, and again towards the end, concerning the importance and extent of medical research that has been done by the Defence Research Board. In a general way, what did it consist of?

Dr. Uffen: Well, there are two main aspects of it. As you know, most medical research is

done in hospitals, or university hospitals, and in the early days after the Second World War the Defence Research Establishment at Toronto was known as the Defence Research Medical Laboratory, and it was somewhat unique in that it was a medical laboratory under federal direction. Its functions have changed over the period of time since so that they are not now really medical in that sense—that is, human engineering, and so on.

The first point is that we did have a medical laboratory devoted to medical research. The second point, I believe, is that in about 1947-48 half of the medical research in Canada got its financial support from the Defence Research Board.

Now, with the appearance of the Medical Research Council and the vastly increased support for university medical and associated biological departments, and hospitals, our contribution is significant but of declining relative importance, and it is proper, I think, for us, in a reasonably organized way, to transfer the responsibility for what we used to do to the Medical Research Cluncil, and this is being done.

However, we still maintain a number of advisory committees of medical specialists who are first-class. So far as I know there is absolutely no question about this. So, we still have available very good medical advice.

The Chairman: With respect to these initial projects that you started, what exactly did you have in mind at that time? Were you trying to meet your immediate purposes, or trying to fill a gap that existed on the general Canadian scene?

Dr. Uffen: I think, both. The justification for DRB's doing it was that under the National Defence Act we had to be able to advise the Minister of National Defence and the Forces in the way, for example, troops live in the Arctic. Clothing and so on for survival in Arctic conditions was a very major problem ten or fifteen years ago—and I am not so sure that it is not still a problem.

Now, in order to solve those problems you have to have both the ideas generated by fundamental research scientists, and a group which is going to direct the results towards the needs of the armed forces, so we had both.

I am told by Dr. Bigelow that in modern cardiovascular surgery they are now using methods of chilling or freezing—low temperature work—which were originally developed as part of the fundamental research necessary to the study of performance in the Arctic.

The Chairman: But how could you transfer your responsibilities and programs to the Medical Research Council since that Council does not have any intramural activity?

Dr. Uffen: Dr. Malcolm Brown, the President of the Medical Research Council, has been long associated with DRB, and he is a member of our medical advisory panel. The transfer of activities takes place by liaison between the groups that screen applications to the Medical Research Council, the National Research Council, and to us, and we just get together and say that it would be more appropriate if it was done by the Medical Research Council, and we suggest to the professor concerned that he apply to MRC.

Senator MacKenzie: The point on page 10 that I had reference to is in this same field. You state that you are establishing a third scientific assistant to the Chief of Personnel who will be concerned with human problems. I take it that "human problems" envisages something broader than medical or health matters?

Dr. Uffen: Yes, we made the appointment quite recently. I think it was a little unfair to say it was established, because the appointment was made within the last eight weeks. The man himself is a psychologist, and he has been one of the senior scientists at Downsview—at the Toronto Research Establishment—and he has the very difficult task of trying to determine what science can do for the armed forces. It will take him a few months to lay out the program.

Senator MacKenzie: This is in the area of human problems?

Dr. Uffen: Yes. For example, there is the matter of recruiting policy, and problems of morale. What happens if we turn off the recruiting for six months, and then later try to turn it on again? It is that sort of thing. If you are going to send troops on peacekeeping roles, and they get a sudden direction to be prepared to go to a tropical climate or an arid climate, then you want to know how they will react. It is matters like these.

We have to anticipate this need, and make sure that we have made the proper studies of

the kind of equipment they may require. We have to engage in studies of a problem that many of you know about. In these days of rapid intercontinental air transport we all know that one can go around the world in less than four days by commercial aircraft, and that if we do our metabolism gets out of whack.

Senator MacKenzie: I know that, sir.

Dr. Uffen: Another example is...

The Chairman: Do you have a cure for that?

Dr. Uffen: I think that if you go in a satellite then you travel fast enough that it does not affect you. Some excellent work has been done at McGill University. I do not know the terminology well enough to explain it, but it deals with the problems of balance, which is controlled by our hearing mechanism. These matters are exceedingly important to people who are in aircraft or in any kind of a moving vehicle.

At Toronto they study the problems of going down into the deep in high pressure vessels, and so on. I understand that this is somewhat similar to being isolated in a satellite.

Senator MacKenzie: I have another question. I was interested in the contribution you have made and are making to and your interest in, the development of a communications satellite. Has that been turned over to another specialized committee or group, or are you still in the field?

Dr. Uffen: It is in the process of transfer. I think from an historical point of view you would say it has been done, but in real time it takes a few months. For example, we still have the money in DRB, or part of it, and we still have the machinery for paying people. We have the machinery and responsibility for maintaining the laboratory, and contracts with caretakers, and so on, and we still have the agreement with the National Aeronautics and Space Administration, and so on. However, by order in council the responsibility for the work is now that of the Postmaster General, and we are working out all the machinery for an orderly transfer as fast as we can.

Senator MacKenzie: But you did the initial work in the development of the communication satellite and that kind of thing?

Dr. Uffen: It was done in two stages. The original satellite work was done in the Defence Research Board laboratories, but it was a deliberate policy to have the work done in industry as soon as possible, so the remaining satellites have been constructed in industry. Our function has been to monitor, to act as the public representative to see that the work is done according to contract and so on.

Senator MacKenzie: This suggests a question in connection with your relations with industry in terms of your research. As I understand it, this might be two areas, or two relationships. First, you would assign to industry the responsibility for major research and development in respect of certain matters, certain articles; secondly, as a result of the research work done in your organization you produce items which are likely to be of commercial and industrial interest. How do you arrange this kind of transfer?

Dr. Uffen: If we start out on a project which we believe is primary defence priority, very high priority—for example it might be a metallurgical one, and I will use this as an example—if we start some metallurgical research in our own labs, in addition we may have a proposal made to us under the Defence Industrial Research grants program by industry, who put up roughly half the money, we put up roughly half the money and foster this because it is in the defence interest. Sometimes they make discoveries which have their greatest exploitation potential in civilian pursuits. We have these interlocking representations with the National Research Council industrial support program on the one hand and what was the Department of Industry on the other, so that when the research phase of it is over and it is no longer really my responsibility it can be taken up and supported in some other way, maybe as a tax incentive or something like that.

I do not remember the name of the firm—which is probably just as well—but there was a $15 million development in a metallurgical process which came out of a project we initiated six or seven years ago. I was confronted with a question by my own deputy minister: "Bob, whatever are you spending defence money on a civilian project for?" My answer was: "In the first place, we thought it was in the defence interest. In the second place, we did not know it was going to be a success. In the third place, we made efforts to transfer it

to a civilian organization, and this has now been done."

Senator MacKenzie: Naturally I am interested in the relationships with the universities. Are the research projects undertaken in the universities at your request or instigation, or are they presented to you by individuals within the university or both?

Dr. Uffen: Both. A small amount of money is spent at our request; it is a contract. We have a definite objective, the university accepts the contract or it does not, and we get done what we want. Sometimes the best man in the country is in this university or that university. However, most of the money is under the University Grants Program. In this case the university professor makes application to us. We have to judge his application a little differently from the National Research Council. We maintain the same criteria for excellence and so on, but we have to make a subjective assessment whether it is in the defence interest, as we see it, and we can support it, or whether it should go to the National Research Council. I might say that we are able to grant only slightly over half the money requested; in other words, we always spend all the money there is in that area.

Senator MacKenzie: Am I right in believing that the work done in the universities is not classified work?

Dr. Uffen: It is unclassified.

Senator MacKenzie: It is open?

Dr. Uffen: It is open. As you know, I was Dean of Science at the University of Western Ontario, and while there I took the point of view, which I still hold, that it would be a mistake to have directed research of any kind, particularly classified research, in a university. I am quite happy at the moment that we are not suffering from the malaise that is present in the United States, because we do not have that problem.

Senator MacKenzie: I could not agree with you more about your problem of the increase in age of your personnel, because I think it is common knowledge, or at least a commonly held general impression, that the best work in science and research is by and large done by younger men and women, who as they grow older contribute in other ways to society and the community. I do not know how to deal with that problem, but I am conscious of its importance and I am glad you have put it on your list of problems. Related to it, I note that the members of the Defence Research Board and the agencies are not under the Public Service Commission. Is there or has there been any feeling on the part of what was the Civil Service Commission or your members about this difference, as it were, in status–

Dr. Uffen: I think in the past, say 10 to 15 years ago, there was a very big difference of opinion, but times have changed and I think the differences are minor. I know of no serious problem. The reason why the differences are now minor is that the scientific and technological competence of other government departments has climbed enormously. For instance, the Department of Energy, Mines and Resources has a larger group of scientists than we have now, and they are very good. That has made a difference from the situation at the end of the war. Also the advent of collective bargaining in the Public Service makes it necessary to have a good deal more consultation, and while theoretically I have authority to propose some personnel policy divergent from that of the Public Service Commission, I think it unlikely that I would ever get it approved, unless it had very good justification.

The Chairman: Does it give you more flexibility?

Dr. Uffen: Oh yes. In the past the flexibility of being an independent employer has been crucial. It is still very important to us.

Senator MacKenzie: By and large your staff prefer that independent status because of the flexibility?

Dr. Uffen: As far as I know they are quite happy with the separate employer status. Of course, there are very competent staff associations now, so perhaps you should direct your questions to them. I may not be seeing things through the same window.

The Chairman: But from the point of view of the institution itself, in its administrative policies, it gives the institution much more flexibility by having that kind of status.

Dr. Uffen: Mr. Houlding is the chairman of the Standing Committee of the Board which does all this. I do not do it. This guarantees fair treatment to the employees. Perhaps you would like to hear from him.

Senator MacKenzie: Have you any comments on this, Mr. Houlding?

Mr. J. D. Houlding, member, Defence Research Board; President, R.C.A. Victor Ltd.: I think that separate status is a very essential element for the Board. We are in highly specialized areas. We are competing with industries, not just in Canada but in the United States, for the best of talent and without this flexibility we could not achieve this degree of excellence that has been demonstrated. I think this is a very useful difference.

Senator MacKenzie: I have some other questions, but I will yield to other senators.

Senator Kinnear: Mr. Chairman, Dr. Uffen and gentlemen: I would like to ask you if you are doing research in the area of conflict resolution. I will give you all my questions together, contrary to the way Senator MacKenzie did it, and then you can sort them out.

Peace is, no doubt, the best defence against warfare. The very large nations may look upon their very large strategic arsenal as a means to peace, in a situation where there is a balance of power. Small and medium sized countries, by aligning themselves with major powers, can partake in this kind of peacekeeping; but small and medium sized powers, purely on the strength of their military forces, cannot be a sole determinant in keeping the peace. The most effective role of the small or medium sized nations with regard to peacekeeping would appear to be that of a spokesman for peace—by the way, I am not a pacifist, in any way—a negotiator of peaceful settlements or as an agent for the resolution of conflicts.

Here is where, of course, we wonder if we have gone into this area. On the assumption that peace is the best defence against warfare, would it not be possible to include, in the area of defence research studies, programs designed to carry out research in conflict resolution?

Surely the resolution of conflicts, before they result or become a large scale war, is the most effective role of a small nation? Could not research be done in which the social, psychological and economic factors associated with conflicts might be identified?

Certainly, the history of the recent past is crowded with examples which could be studied—and you can run from the Korean war to the present invasion of Czechoslovakia. These examples certainly could be studied.

One would hope that, on the basis of such research, new tactics might be found by which small nations could resolve conflicts before they flare into warfare.

There is an article I would like to read, on "weaponry" from a publication on "Weaponry". It quotes Kenneth Boulding as follows:

> Kenneth Boulding has often remarked that threat systems are sick. In a sense, they certainly are—in the sense in which a failure of the stability of the system could result in unprecedented disaster. It is for this reason that I am personally sympathetic to a fundamental overhaul of the world order. But we should recognize that there is another sense in which threat systems are not sick: It will at best take some time and trouble to establish...

And here is the point...

> ...a replacement system, and threat systems may have a lot of vitality for maintaining the peace in the meanwhile.

Do we not have to do research on conflict resolution, to help find the replacement system?

In the American publication, *Science and Technology*, the author, Dan Cooper, suggests that, in the United States, 0.1 per cent of the budget should go into the research of the causes of aggression between men and between nations, and that in the United States there should be about $80 million. He said that a longer term investment in research may be our best hope to break the threat and counter threat.

Finally—and Senator MacKenzie talked about this, in part—the Department of National Defence has recently established a number of professorships of military and strategic studies in selected Canadian universities. To what extent will their studies deal with conflict resolution, human aggressiveness and the underlying causes giving rise to war.

Dr. Uffen: I will start with your comment about conflict resolution. We do a small amount of work in this area. A part of the university grants program is devoted to applied psychology, and we have a number—I do not have the detailed number here but it is listed in Appendix IX—of projects supported in universities, in psychology, and some of

them are concerned with conflict resolution. But they are modest, I admit that.

We have recently initiated, under the university grants program, a deliberate policy to support applications from professors in the social sciences. It will take a little while to build this up. It is very modest right now, but we have one or two grants to professors in sociology and economics. They are related. I would not like to say that the titles are concerned with conflict resolution. I think it is one of the things that Dr. L'Heureux and I recognized, when we became chairman and vice-chairman of the Board, because he undertook a study of all our activities. The DRB had a large complement, first of all, of physicists, chemists, engineers and so on, but many of the problems of the Armed Forces in their peacekeeping role were sociological problems, so we have initiated support in this area. It is just under way.

Your next comment, Senator, was about replacement systems versus threat systems. Yes, we would like to do more work in this field but again I must say that we have only really initiated some serious research fairly recently. You recall that, in my introductory remarks, I mentioned the Defence Research Analysis Establishment, which has grown out of what was known as operations research. We have re-organized it slightly and I am trying to increase the number of people in that establishment up to ten, if I can do it. The kind of person who will go into the establishment might be a mathematician or a statistician—you always need them—but certainly we would like to have economists, anthropologists, sociologists, to allow us to undertake some more of these studies.

You probably are aware that I made an address to the Canadian Association of Physicists last spring, where I talked about the inter-relation between social sciences and natural sciences. Many people thought it odd that a physicist like myself should be the one who has undertaken to introduce or explain our activities in social sciences.

The Chairman: May I ask you at this point, is there any liaison with the Canada Council when you go into these fields?

Dr. Uffen: No, Mr. Chairman, except that I talked to M. Jean Boucher. We have not any effective liaison yet.

Senator Kinnear has mentioned the professors of strategic and military studies. There is a little study of it in one of the appendices here, but I think I can recall most of it. The Armed Forces were obliged, or decided, to terminate some of their traditional programs in the universities. They were very reluctant to do this but they decided they had to; but they did not want to lose contact with the oncoming generation of young people, they did not want to lose contact with the minds and concepts that could be generated in universities.

So they introduced a proposition that the Department of National Defence undertake to support the establishment of several professorships of military and strategic studies. The proposal was drafted and worked out through consultation with the Association of Canadian Universities and Colleges, and was given to the Cabinet about a year ago. Although I forget the exact date, the Cabinet did give approval to the establishment of six such professorships and authorized the expenditure of approximately one quarter of a million dollars.

Up until this time the Defence Research Board had very little to do with it, although I, as a member of the Defence Council, did know it was going on. At that stage we had to decide how we would implement it, and the policy decision was that it would be best if those universities who were interested would make a proposal as to what they wanted to do in the field of military and strategic studies, because the Defence Research Board has long been in contact with universities.

It was suggested by the Association of Universities and Colleges of Canada that we administer it. We did not ask to do it; they suggested we do it because of our already established machinery. One of the methods suggested was to have a screening committee to judge applications from professors in universities. Therefore, a screening committee was set up under the chairmanship of Mr. Arnold Heeney, who is very knowledgeable in this area—perhaps we can skip that. Applications were invited through the Association of Universities and Colleges of Canada, and 14 applications for six professorships in varying degrees of preparation depending upon the facilities the universities already had, were submitted.

The screening committee approved five of these applications, and the money has been provided to the universities for these professorships. Now, the intent was not for the

Department of National Defence to tell the universities what to do; the intent was to make it possible for universities that wanted to, to have a centre of excellence where minds could meet to do research in the areas of strategy, that is, national security in a Canadian context. We take so many of our strategic concepts from the United States, United Kingdom, NATO and others which have to be related to Canadian concepts, that that was one of the fundamental purposes of it.

Now, there are a couple of minor additional comments I would like to make. We also made provision for some research fellowships and scholarships because a professor needs to have around him some graduates—young people with whom he can work. We made provision for library facilities so that they could start a library if they did not have one.

The requests came from different areas; some came from history departments—that is fine; some came from political science departments—that is good; some came from sociology departments. It depended on the interest of the local university, and I think it is safe to say that I am enthusiastic about the way the program is proceeding. It will, however, take two to three years before something will emerge that we can evaluate.

Senator Kinnear: Thank you. I think it is quite a new idea; this idea where we can study why we fight with each other.

Senator Bélisle: Mr. Chairman, first, I would like to say that I am very pleased to hear that you agree with it, and, second, I would like to say how much I appreciate its condenseness. It was very precise, especially with respect to Annex I-11, and it will give us, I believe, a very good opportunity to study who's who in the echelon or command or responsibility. I was also pleased to hear that you are making use of the talents and facilities that we have in our universities.

On page 14, paragraph 46, you state that approximately 22 per cent are effective in both our official languages. My question is this, what portion of this is outside of the province of Quebec?

Dr. Uffen: It is quite variable. I am not sure that I can give you a precise figure, but I would say that three quarters of the competence is due to the fact that we have a laboratory at Valcartier—one of the charts shows that at Valcartier 75 per cent of the professional people are fluent in both languages. I believe that one of the other charts shows zero fluency, but Valcartier is a large one so it increases the average. We do have a very substantial bilingual competence where it is needed, and I would like to claim that this is largely through the efforts of Dr. L'Heureux. We have anticipated this national need, and we have had a bilingual competence in our headquarters for a year now.

My French is equivalent to grade 13, Ontario. It is a bit laboured, but I can understand. If someone wishes to deal with us in French, we can deal in French, although you would not, surprisingly enough, think so at Esquimalt. We have a good bilingual competence in British Columbia, although I forget what the actual figure is.

Senator Bélisle: Thank you, Dr. Uffen. From what you have said, I would like to let you know that there are two other bilingual universities, Ottawa University and Laurentian University.

I would like to ask Dr. L'Heureux a question. What universities receive subsidies, or grants, from the Department of National Defence? And how are these grants obtained?

Dr. L'Heureux: Mr. Chairman, all Canadian universities can receive grants from the Department of National Defence, according to the requests made. Presently, as you have seen by the tables we have submitted, most universities receive grants from the Defence Research Board. These contracts must have, in addition to excellence, a certain military implication in the proposals submitted. Now, from the point of view of selection, we have a selection committee whose chairman is a university man, as well as most of the members, with the exception of our Chairman and myself. This committee does the selection of the projects that are submitted and, as mentioned by our Chairman this morning, we have twice as many requests as we have grants. In general, all the universities submit requests. Obviously, universities in the large centres have more facilities, in general, than the universities which are beginning, and when it is possible for us to help a new university, whose scientific point of view is excellent, but not totally military, we grant it financial assistance, if possible.

Senator Bélisle: To follow up the statement presented on page 23, it has been mentioned just now that there were 50 university

projects accepted for a total of $13,000,000. Is there a procedure to assist bilingual universities. Is there any hope for the University of Sudbury?

Dr. L'Heureux: Yes, Mr. Chairman. We have French universities, as well as bilingual universities, receiving grants. We award many grants to Laval University, to the University of Montreal and to the University of Ottawa. On the other hand, the University of Sherbrooke and the University of Moncton receive smaller grants. I personally had talks with the representatives of Laurentian University in order to explain to them the type of work that we would undertake in the future and the manner in which to present a request to receive grants from the Board.

Senator Bélisle: Thank you.

[*Text*]

Senator O'Leary (Carleton): Mr. Chairman, I may say that this question is perhaps more to satisfy my own personal curiosity than to prosper scientific research. Last year the United States adopted a new system of missile defence, and I believe they called it the high altitude radar observation system. I understand they sent to Ottawa a man from their military research department to discuss this matter here in Ottawa. Now, what I would like to ask is this: Did this gentleman come here to consult or to inform? In other words, did he come to ask you what you thought might be done, should be done or could be done, or did he come to tell you something that had already been done?

Dr. Uffen: They came to consult with us on a technical level. Consultation on such a level is easy. On a diplomatic or government level, it has to be a little more precise. It is relatively easy for the scientists and engineers to consult because we don't make commitments. So, on the scientific level we were consulted. I think it is appropriate to say when we were given certain basic information we went back and thought about it, and we found we didn't have all we needed. So we did two things; we sent some of our scientists to the United States to consult and ask questions and get further information, and we got to it. I also asked one of my own old friends who is a scientist of some standing at a university to do some work from first principles as a check to see if what I was being told added up, and it did. Then we made our own study in Canada —the Defence Research Analysis Establishment has made an intense study of our own. This was done quite some time ago and the ramifications are still being discussed.

Senator O'Leary (Carleton): Thank you.

Senator Thompson: I would like to underscore the remarks and the questions of Senator Kinnear. I think we have a unique geographical situation and a unique climatic situation and so on and because of the mixture of our population we have an opportunity to establish a unique social laboratory. We have learned to forget our historical differences, and our racial and cultural differences, to work together and I think to this extent we could be considered a laboratory that could be carefully studied as an experiment for the world. However, if I could now refer to a question by Senator MacKenzie with regard to older personnel, I notice there is concern expressed in your paper about this and you talk about portable pensions and forced attrition. I have been wondering whether if in working in a close liaison with industry some of your older scientists might not work in executive positions and as advisers and so provide opportunities for younger men to come to you.

Dr. Uffen: We have not done so yet. The problem has only arisen over the last year or two. But it is something we have to face up to, and I would be glad to examine any scheme that would allow greater mobility of our scientists in and out of government, in and out of the universities, and in and out of industry. But the older men have an investment, as you well know. It is not easy for a man of 55 years of age to uproot himself and move to a new area and start over again, and those are the ones I am worried about. Such a man has 10 years to go to retirement, and all executive positions have been filled by 44-year-olds like myself. I look and wonder what is to become of me. This problem is not confined to DRB at all. We are all old at 30 now.

The Chairman: I wonder if Mr. Houlding would comment on that. We discovered yesterday, for example, that industry has not been as interested in industrial research as could be expected, and that perhaps the lack of scientific advisers in industry, close to management, is the reason for this lack of interest. To pursue the idea a little further, I wonder if it would not be possible, for instance, for the Government to offer a kind

of incentive or to pay at least part of the salary of these people who could be transferred from government to industry, where I am sure they would be in a position to play a very interesting role for 10 or 15 years.

Mr. Houlding: To get such interchange would be a very good thing. We have the same problem in industry. The only solution is growth. A relatively small percentage of older men fulfil such a function.

The Chairman: Your industry is not typical, because I am sure you have quite an important research program. But for those industries of firms which do not have such programs and which are not even in the position to use the information which becomes available, perhaps there would be a role for these people to play.

Mr. Houlding: I don't like to be negative about this, but I think it becomes a purely economic consideration. To begin with, a relatively small company cannot afford research, and even if it is going to put money into research, it is going to put it into applied research, and the older scientist is not likely to be a natural candidate for that kind of work. I think the concern here in DRB is partially the result of financial constraints they have, and for these and other reasons the percentage of the older scientists is a problem.

Senator MacKenzie: In the table on page 22 you have omitted completely Prince Edward Island. Now I am not a Prince Edward Islander, but I think for reasons of diplomacy it might be better to have it in there. It may be that some time you will have someone at Summerside doing work.

Dr. Uffen: We thought it might not be very diplomatic to put it in there with a zero.

Senator Giguère: I am referring to research grants to industry mentioned on page 19. What provision is made for reimbursement of grants to an industry when a sizeable profit is made by that industry from products developed as a result of such a grant?

Dr. Uffen: None. It is bread upon the water. You have about one success in 100 tries. Fortunately when you are successful, the return is 100 to one. However, we take the point of view that our job is to foster this, and ever since the Second World War it has been the DRB's position that we must foster research. It is the function of the Department of Industry and other agencies to see that it gets exploited.

Senator Bourget: Could they not reimburse the money that you have invested in that industry? I think that would be fair.

Dr. Uffen: Well, they are required to exploit it in Canada. We get reimbursed by the production orders and the exploitation that takes place. I would imagine that R.C.A. Victor, for example, have done well out of DRB support for satellite research.

Mr. Houlding: If you would like me to comment, I would say every dollar we get goes back in trying to keep pace with the industry. It is a very fast moving field, and it takes us all our time to keep up with it.

Senator Grosart: In Appendix D, Annex II, paragraph 2, I read the statement:

> DRB is now engaged in developing a method to relate research projects to military functions.

Does this mean you are developing a method of surveying all the R and D projects taking place in Canada, including industry, universities, National Research Council, departments of Government, crown corporations, and so on, to see what basic or applied or development research might have military uses?

Dr. Uffen: No, it means we are studying our own program to be able to demonstrate that we are doing certain kinds of research in terms of the needs of National Defence—but it is National Defence.

Senator Grosart: Then how would you relate the R and D that is going on, the $800 millions worth we were told about yesterday—that is, R and D by governments, industry and everybody—how would you know whether something of military application might be under development?

Dr. Uffen: We would rely very largely on our advisory committees structure. Our advisory committees have representatives from other Government departments, industry, and so on. These would go into the machinery in time to prevent us from some unnecessary duplication. There is always a certain amount of duplication in research, but we try to prevent unnecessary duplication. That is one method.

Also, the scientific literature, the engineering literature, is available to us, and our 600 professionals are all members of appropriate learned societies and professional organizations, and they read and study beyond the immediate problem.

Senator Grosart: I realize this is only a very small part of a much larger problem, of what is going on in the world, but I notice that you, for example, have bilateral agreements...

Dr. Uffen: Yes.

Senator Grosart: ...with certain NATO countries.

Dr. Uffen: Yes.

Senator Grosart: But not with all of the NATO countries. Is there a reason for that?

Dr. Uffen: Are you referring to Portugal, perhaps?

Senator Grosart: Well, Belgium, I believe, is not in your list.

Dr. Uffen: The bilateral agreements are largely due to the initiative of a defence scientist in one of the NATO countries who had a problem that he recognized we could help him with, and then a formal arrangement was made so that we could communicate legally. I do not really know why there is not one with Belgium. I could understand why there may not be one with a small country because of their limited activity.

Dr. L'Heureux: I believe I may be able to help on that. Belgian research is not organized the way we are in Canada, to start with. They have civil research and all the other done within the military, mostly through universities. So, the main link that has been established with Belgium has been with NRC on the one side, and the military, on the other, but their organization is very different. This requirement, so far, has not developed into a Belgium agreement.

Senator Grosart: I presumed there was some simple explanation.

Again, in your statement, doctor, you spoke of the U.K.-Australian agreement as the most important international program of exchange of science information. Can you tell us why this particular one has this importance, in your estimation?

Dr. Uffen: It started out originally as a tri-partite agreement between the United Kingdom, the United States and Canada, and I think the reasons are historical, as an outgrowth of the Second World War. Then, at a certain time in its evolution, Australia, I think, requested, or it appeared highly desirable for Australia to play a part too. So what was originally tri-partite is now quadripartite.

Senator Grosart: Is the United States in that?

Dr. Uffen: Yes, the United States and the United Kingdom. This is why I said it was the most important one of all. If this were not there we would be severely handicapped; we would be hamstrung. You belong to a club and pay your membership, but sometimes the junior member gets a lot more from the club than the older ones, if he is reasonably discreet and plays according to the rules, and he gets back ten times what he put in.

Senator Grosart: And still plays golf!

Again, I will not cite the reference because it is an obvious one. The division of responsibility for R and D within your structure, you say, is different from that of other comparable countries. You suggest this may be a disability in the functioning of your own R and D. If that is so, could you tell us why we continue it, and what would be the alternative, if we draw ourselves more into line with the common practice of other countries?

Dr. Uffen: Well, first of all, I think I said within the western alliance; it is not really comparable countries because Australia, I suppose, is about the only one that is really comparable. It was when we deal with massive, large organizations like in the United States and the United Kingdom. In the United States, with such an enormous requirement for machinery, and so on, they have a single organization to look after it all. We cannot afford to have, and I would say there is not really the need to have one big, massive organization which does the research, the applied research, the development, the purchasing and all the rest of it. We cannot really afford it.

But I have to work with countries that have a structure that assumes that. So, the difficulty we run into when we deal with the United States and the United Kingdom is that General Waldock and I have to get together and say, "Who will we send? Is it better to

send a civilian engineer or a military officer or a DRB scientist?" And we have to get together with the Department of Defence Production or the Department of Industry. This is a little inconvenient, and I do not have any recommendation that I am convinced would be better.

Senator Grosart: But the other countries, using the unitary system within the western alliance, are no bigger than we are.

Dr. Uffen: We mesh very nicely with Norway, and we do not have any problems with them because they have a very similar structure to ours—and the Netherlands. So, we have no problem there. It is just when we try to figure out who is the right person to talk to our representative in the United States. For example, my counterpart in the United States is Dr. Foster, in the Pentagon. I go down and talk to him. He is responsible for defence problems, production, and so on, far beyond my responsibility; but, surprisingly enough, I am responsible for running a laboratory network. He has none of those operating responsibilities. I talk to him about collective bargaining problems, and he says, "You have my sympathy." You see, he does not have the same kind of problems.

Senator Grosart: That is all, Mr. Chairman.

Senator Cameron: As a member of the Institute of Teaching Studies for a number of years I welcome the establishment of these professorships in the universities, and notably the one at Carleton. But, in recent weeks I have been having a confrontation with a relatively articulate and aggressive group of student activists in a number of universities. This is one of the areas on which they seem to be zeroing in. It is quite obvious that they are grossly misinformed. I am wondering what steps can be taken, or have been taken, to put the thing in proper perspective, and to get more accurate information out to the public in general.

I ask that because these people have had a tremendous amount of publicity, and they have been given a wrong impression as to what this professorship at Carleton is all about, and they are linking it up with the research centre that was established at Columbia. So far as I know, the Columbia operation was a much larger and much more inclusive operation than was ever proposed in Canada. I would like to know just what is being done, or what has been done, with respect to getting the facts out. Secondly, I should like to ask: Is there any relationship between what is being set up here and what has been set up at Columbia? I believe the Columbia thing has been disbanded as a result of this action.

Dr. Uffen: Well, I can answer your first question. The Canadian Union of Students sent one or two representatives to DRB a couple of months ago. We have an executive secretary for university affairs, and he spent four hours with them. He gave them the information about our research grants for universities, and he gave them a copy of our annual report, which they had never seen. He explained it all to them, and they have not been back.

I might make another comment. Under the circumstances, it might have been a mistake for me or one of my staff to explain the Carleton program, because people who do not want to believe you would say: "Ha ha, direction from the Defence Department", so we keep quiet.

Dr. Davidson Dunton did a rather competent job in his own right. After all, he is the university president. The program had been approved by the university senate, and so on. So, we might only have muddied the waters in meddling in what is a university program.

The Chairman: Senator Hays?

Senator Hays: Doctor, I should like, first of all, to say that this is one of the best papers I have had an opportunity of looking at, and I think you should be congratulated on it. I do have a few questions to ask you.

First, do you have any statistics on the economic benefits that have been obtained from research in the last few years, or do you keep a note of this sort of thing?

Dr. Uffen: Well, we try, and like everyone else we find it is not easy to determine all the economic benefits, but there is a demonstration in one of the appendices. It is Appendix VIII, page 25. There is a table there which gives some of the economic benefits of Defence Research Board work, and it tabulates under the fields of telecommunications, navigation, and electronics, et cetera, a number of projects which we initiated at various times in the past and which are known to have resulted in Canadian production orders which totalled something in the vicinity of $200 million.

Now, we did not do all that by ourselves. The ideas and programs were generated in DRB, but the subsequent financial support, or the major developmental support, might have come from the armed forces vote, or from a Department of Industry vote. However, they were all generated by our people.

If you look at this you will find that about three of the items account for most of the return—the airborne Doppler system, electronic components, and the anti-submarine sonar system. This is why I said a little while ago that you have about one success in a hundred, but when you have a success you may get back a many-fold return.

Our major concern is national defence and advice to the minister, and if something like four times our annual budget happens to come back into the Canadian economy then that, from my point of view, is gravy. That is not what I am here for.

Senator Hays: Your budget is around $50 million?

Dr. Uffen: Yes.

Senator Hays: When the minister or the deputy minister comes along and says that you have to cut your budget by ten per cent—which often happens—then, in endeavouring to take out the ten per cent I suppose you look at the programs and say: "While this particular program is important, we will just have to take this particular ten per cent out of it"? You are not permitted to retain any portion of the $50 million that you have not used?

Dr. Uffen: No.

Senator Hays: It just goes back into the general funds?

Dr. Uffen: Yes.

Senator Hays: I suppose the purpose of this committee is to make certain recommendations to the Government, which we hope they will accept—at least, in part. Would this be an advantage to you?

Dr. Uffen: Well, I can make the first obvious observation. The total expenditures on R & D of the Armed Forces and DRB are approximately $80 million, depending upon how much of the armed forces salaries you include for R and D. This is about 5 per cent of the defence budget. I think it is a bare minimum, but in times of restraint we have to live with it. So, one thing I would like to have recognized is that we are at the bare minimum threshold of a reasonable investment in R & D from the point of view of national defence.

The other comment I wanted to make—well, I had another comment, but it has slipped my mind.

Senator Hays: I asked whether it would be of benefit to you if...

Dr. Uffen: No, I can live within a budget when I am told: "Here is a budget. Make it work", because research is something you can cut out and put in. Everybody knows that. But, what I would like is internal flexibility so that I am able to terminate a program which we regard as having low priority in order to start something new, such as we were discussing earlier, and which now I find rather difficult to do.

In the past our funds were made available in such a way—for one thing, I cannot change salaries. A salary vote is a salary vote. In the past money was given to our laboratories, and we could not transfer funds from one laboratory to another.

I believe the Treasury Board, because of its new policies of programmed budgeting, is going to reconsider that, and give me an internal flexibility that will allow me to transfer money from one project to another, regardless of whether it is in this lab or that lab.

Support for this would be a real help to me.

Senator Hays: May I tell a little story, Mr. Chairman? I am the chairman of the Cancer Crusade in the Province of Alberta. We are supposed to collect money, and not have anything to do with the spending. But, I was interested in finding out how we were using some of this money.

We have a little cancer research institution in Edmonton known as the MacEachen Cancer Research Establishment. I have been there two or three times now. They started some time in the 'thirties. There are many different kinds of cancer. I am a layman but I understand that every kind of cancer is different from another. In 1932 a woman died from a form of cancer whereby the abdominal cavity filled up with a sort of leukemia. They have been perpetuating this cancer in mice. They use about 10,000 mice a year. Some more are

on the way there now, because most of them are dying of cancer.

They have been using several hundred thousand dollars to keep the program going in an endeavour to keep the establishment together in order to discover other areas in which they can do cancer research. In the meantime they have been able to come up with certain drugs which are being used today, after 25 years of that sort of research which keeps an establishment of about 25 people busy. You must have exactly the same sort of disciplines in your field of research, doing the same thing, trying to hold the $50 million budget together without losing it so that you can use it in other directions. This was the reason I asked the question. If you put aside the money that you were not using you could probably use it more effectively a few years from now, in your discretion.

Dr. Uffen: First of all, I do not know that we have any money we are not using.

Senator Hays: I am sure of that.

Dr. Uffen: Perhaps you might like to hear from Dr. L'Heureux, because he is the chairman of our program review group, who have this harsh task of deciding when to terminate a project so that we can start another one. It meets about once a month or more.

Dr. L'Heureux: There is no doubt that a good research program will perpetuate itself, as you say. On the other hand—and this is why we have adopted this method that I talked about very briefly this morning of assessing our program—we start with the military requirements, and this changes considerably. We have developed, and are still developing, this method of coming from the military requirements to military activities, to subactivities, to technology and then to science. The technology and science are both of interest to us. Internally we do some technology, and with the universities more science. On average about once a year when the science budget is exhausted we have to cancel a major program. I do not say there are now some that should not be cancelled; there are other restraints sometimes; there are people we have to worry about, facilities and money. In general we start a new program about once a year on average. We run about 20 major programs. This is one of the reasons why in the scientific community we are frequently criticized of changing direction too often, because we always have to serve a customer who is often changing his requirement because of change in government policies, change in threat, you name it. We do have these problems.

We think we are developing a very effective way of assessing our programs. I know the military have told us that the support we are giving them now is much more direct than it was, say, five years ago. We do change programs, but there is no doubt that it is very difficult, because primarily it is people.

Senator Grosart: Do any of the $200 million industrial production orders you have had through DND research stem from the $28 million you have put into development research grants, or do they come from your intramural research?

Dr. Uffen: Those were intramural.

Senator Grosart: All from intramural?

Dr. Uffen: Yes. I have not tabulated the ones that may have arisen from the industrial support because we asked for returns and so on. It is the company's business. After all, they have a 50 per cent investment in it and when it starts to pay off they tend to clam up.

The Chairman: We will adjourn until 3.30 this afternoon, when we might continue with Dr. Uffen for a few moments, because I notice there are a few questions senators want to ask, and then we will proceed to our second item of business.

The committee adjourned.

AFTERNOON SITTING

Senator Maurice Lamontagne (Chairman) in the Chair.

The Chairman: Honourable senators, I think it would be more convenient if we proceeded immediately to hear Major-General Waldock. I have had a word with him and he feels that many of the questions could be addressed to all the group after he has spoken. If that is convenient, I will ask Major-General Waldock to make his statement.

Major-General D. A. G. Waldock, Deputy Chief of Technical Services for Engineering, Canadian Armed Forces: Honourable senators—

1. You have heard Dr. Uffen's presentation on the activities of the Defence Research Board. This second brief presented on behalf

of the Department of National Defence covers those activities of interest to you which fall within the responsibility of the Armed Forces.

2. In oversimplified terms, the Defence Research Board handles the "research" activities of the Department and the Armed Forces handle the "development, test and evaluation" activities, in addition to the much larger engineering commitments associated with the acquisition of their equipment. In fact, of course, the dividing line between the two elements of the organization is more diffuse. This is inherent in the very nature of research and development, where there is a continuous technical transition from scientific research at one end of the spectrum through applied research and development, to production and acceptance at the other end. Within the Department of National Defence we have adopted a standard terminology for research and development activities, which is defined in Annex A to the brief. The Defence Research Board has clear responsibility for basic and applied research while the forces have clear responsibility for their equipment acquisition which includes engineering development and operational systems development when necessary, production design, quality assurance and, generally, all activities associated with specifying, procuring, and introducing new equipment into the service. The forces are also responsible for preliminary development, including its funding, where operational needs can be stated only as objectives, rather than as clearly defined requirements, although Defence Research Board establishments may conduct this work on our behalf. Apart from service test and evaluation, the forces have very little "in house" development capability and it is our policy to rely primarily upon industry, and to a lesser extent upon Defence Research Board establishments. In the development field, therefore, the forces are concerned primarily with the formulation and management of projects which are conducted by other agencies.

3. In the forces, the functions of test and evaluation, standardization and quality assurance are related primarily to equipment procurement, but because they also have some relationship to development the brief contains details of our activities in these areas.

4. The relevant parts of the Armed Forces organization are described in the brief and I should like to draw your attention to Figures 1, 2, 3 and 4. Figure 1 shows the organization directly under the Minister, the Deputy Minister, Chief of the Defence Staff and Chairman of the Defence Research Board. Figure 2 shows the breakdown into Branches under the Chief of the Defence Staff. Broadly speaking, the activities in which you are interested fall under the Chief of Technical Services, who is responsible for all aspects of equipment acquisition and its maintenance in service. The Vice Chief of the Defence Staff is responsible for determining operational equipment requirements and his branch works closely with the Technical Services Branch during the process of requirements definition. Figure 3 shows the Technical Services Branch organization. The functions which are of main interest to you fall under the Deputy Chief for Engineering, which is my appointment. The more detailed organization under my direction is shown in Figure 4 of the brief.

5. I should like to emphasize that the primary function of the Engineering sub-Branch is the management of equipment acquisition. This involves responding to the statement of equipment needs made by the Vice Chief of the Defence Staff and taking all the action necessary to acquire and place the required equipment in the hands of the forces. The majority of this workload is of an engineering nature in discharge of the production design authority function, but it also includes time and cost control, quality assurance, development when necessary, test and evaluation, and the overall co-ordination of the service introduction phase for each new equipment. In this connection, the forces procure new equipment at a cash expenditure rate of about $250 million per year, but the cash value of the total capital equipment acquisition program under our technical management at any one time, either being formulated or implemented, is several times this amount.

6. The development, test and evaluation activities in which you are interested are handled within this organization as part of this overall equipment acquisition activity because they require the same types of professional engineering competence and expertise. Any decision to proceed with a particular development project is taken on the basis of a careful analysis of other possible options for acquisition of the equipment. The organization I have described is therefore not designed primarily with development in mind, but rather, development is included, for reasons

of economy and continuity, within a much larger organization having a broader overall equipment engineering function.

CONCLUSIONS:

7. I should like to turn now to the conclusions which have been drawn in the brief. These are summarized at the beginning of the brief and I propose to say a few words of explanation about each of them.

(a) The total level of defence developments, test and evaluation in Canada amounts to less than 2 per cent of the defence budget but about 10 per cent of the equipment acquisition budget.

Annex K shows that the present level of development, test and evaluation is somewhat less than $30 million per year which, in terms of a defence budget of about $1.7 billion, is rather less than 2 per cent. This level of activity is below that in most highly developed countries. It should, however, be noted that if the research activities of the Defence Research Board and the defence development activities of the Department of Industry are added to this total, it represents about 6 per cent of the defence budget, which is in line with that for other comparable countries. In addition, the expenditures by the Department of National Defence on development, test and evaluation amount to rather more than 10 per cent of the equipment procurement budget. In our particular circumstances, this does not appear to be out of line.

(b) Most of the activity does not involve exploitation of novel concepts.

Perhaps of greater concern than the magnitude of the development effort is its nature. Close examination of Annex O shows that many of the projects are not directed towards the exploitation of innovation which has emerged from Canadian research. With some notable exceptions, the development programme is largely concerned with test and evaluation of equipment developed elsewhere to determine its suitability for the Canadian Forces, with development of sub-systems, modifications and adaptations and interface engineering.

In our circumstances, it is very difficult to avoid this situation. With the natural desire to acquire the maximum amount of the most modern equipment with the funds available, there is a tendency for the forces to prefer the purchase or manufacture under licence in Canada of equipment developed elsewhere. Usually the end quantities of any specific equipment required by our relatively small forces are not large enough to justify support of Canadian development in terms of national defence needs alone. In addition, the forces wish to achieve maximum standardization of their equipment with their allies for operational compatibility and logistical economy. For these reasons, they generally wish to avoid the unique equipments which would result from those Canadian developments which were not adopted by our allies. Factors such as these limit the choice of development projects severely and, at the same time, make the choice of longer term supporting research activity even more difficult. Unfortunately, therefore, when innovations do appear as a result of defence research, it is not always possible to support them from National Defence resources to meet Canadian defence needs alone.

At present, as in the past, the Armed Forces depend upon the Defence Research Board as a primary source of innovation.

(c) The organizational separation of research from development presents some difficulties but the interface must be viewed in relation to the other interfaces related to engineering, maintenance, supply and requirements definition.

In view of the absence of a clear interface between research and development, it might be argued that the divided responsibility for the two is not desirable. On the other hand, the Defence Research Board, as a separate civilian defence science agency, has been found to have some clear advantages which have been well recognized from the military side. The Board has attracted competent scientists of high calibre through its favourable environment and personnel arrangements, and the research program has yielded large dividends through various international arrangements as well as through internal efforts. The organizational separation does tend to produce an element of remoteness between the scientists and engineers in the two groups, but this has been offset to a large extent by the location of Defence Research Board scientists in the military organization and of military officers in Defence Research Board establishments and through other more formal channels listed in Annex C of the brief.

However, there is also a major interface between development and the engineering associated with procurement of the end item and since nearly all of the Armed Forces development is heavily oriented towards the acquisition of equipment to meet operational requirements, the resolution of this interface becomes paramount. Nowadays, there is an increasing tendency to overlap equipment production and development phases in the interests of saving time and money. There is also an increasing tendency, in both the private and military spheres, to manage equipment systems on a life-cycle or "cradle to the grave" basis both to provide continuity and economy of expertise and to achieve the optimum trade-off between capital equipment costs and maintenance costs.

While it is possible that the present arrangements may not be ideal, it should be noted that most countries have spent many years searching for this ideal with, as yet, no clear evidence that it has been found. It is also important to recognize that the research and development interface is only one of several that exist in relation to defence equipment. In addition to the major interface with engineering for production which I have already mentioned, there are also interfaces with maintenance, supply and requirements definition. In view, therefore, of the nature of the activities covered by development in our case, it would not be very practical to separate it from the test and evaluation function, the engineering design authority function associated with procurement, and the maintenance function. Conversely, if development were conducted by another element of the organization, there would undoubtedly be some duplication of effort with the Engineering sub-Branch.

Examination of the nature of all these interfaces leads to the conclusion that no single formal organization can satisfy all the requirements and the present organization is working well from the Forces viewpoint.

(d) The effective formulation of projects in the overall national interests presents some difficulties.

The difficulties of selecting development projects to follow up the innovations emerging from the research program have already been mentioned. However, the Forces do recognize that there is a clear need to support development in industry if strong, healthy and competitive defence industries are to be preserved. The major portion of this latter responsibility belongs to the Department of Industry and that department has a substantial amount of funds to support development projects aimed primarily at the defence export market.

The brief describes the co-ordination arrangements between the two departments and their respective development programs. As you will note, there is a considerable amount of co-operation, and Department of National Defence resources are, on occasion, utilized to a substantial extent in support of defence export programs. However, the difficulties referred to are making it increasingly apparent that Department of Industry support and associated export interest will be required to an increasing extent if the innovations produced by Department of National Defence research are to be exploited. On the other hand, it is equally clear that defence development projects funded by the Department of Industry require support from National Defence facilities and experts, and also that foreign sales are strongly dependent upon the level of the Canadian Forces interest and support.

It is perhaps obvious to say that the most desirable defence development projects are those which, at the same time, meet Canadian defence needs, have high export potential and serve to expand the industrial technology base.

(e) In spite of the difficulty of selecting and supporting development projects, there are several reasons why it is important to do so.

While there are difficulties in selecting worthwhile development projects, we are convinced that it is essential to conduct some development within the Department of National Defence. Firstly, there will undoubtedly be occasions when development is required to meet unique Canadian requirements which cannot be met in any other way.

Secondly, some development activity is essential to maintain the knowledge of advanced technology which is required for sound decision-making related to the acqui-

sition of complex defence equipment and to provide training and experience for the technical officers required to acquire and maintain the equipment in service.

Thirdly, if we are to retain access to the immense pool of allied scientific and technical information, it is necessary to make a reasonable contribution to it.

Fourthly, if we maintain a scientific capability, it is inevitable that novel concepts will emerge, and it is most desirable that these should be exploited if certain criteria can be met.

Fifthly, and by no means least, development activity is essential if technology-based defence industries are to be maintained in Canada. As stated in the brief, this responsibility belongs primarily to the Department of Industry but it does involve the Department of National Defence to a substantial degree.

(f) Most development projects will involve minor improvements and modifications to existing equipment or sub-systems.

In the light of the observations already made, it will be obvious that we shall rarely initiate the development of large and complex weapons systems to meet the needs of the Canadian Forces alone. Our development activities will usually be concerned with the development of smaller systems or sub-systems based on Canadian innovation, with the adaptation of equipment available elsewhere to suit Canadian Forces needs, and with the improvement of existing service equipment to make it more effective.

(g) Co-operation with our allies in joint development projects is desirable.

The advantages of conducting development projects jointly with our allies are fairly obvious; the cost is shared, the volume of the production run is increased and standardization of equipment within operational theatres is achieved. Our policy is to participate in joint projects when circumstances permit. At the same time, the practical difficulties of harmonizing operational requirements both in kind and in time, and establishing a mutually attractive basis for joint development among several countries must be recognized and it is probable that only a small number of joint projects will be established.

(h) Most developments are conducted by industry on contract.

The Department of National Defence policy is to involve industry in development projects as much as possible. Only when appropriate capabilities do not exist in industry is work undertaken in Department of National Defence facilities. Work which is undertaken within the Forces or in the Defence Research Board's establishments is usually confined to systems analysis, fabrication of experimental or breadboard equipment, modifications to equipment, and test and evaluation requiring specialized facilities and military personnel. However, when our development is carried out in industry, it is still necessary for the Forces to formulate the project, define the tasks, monitor the contractor's activity and inject the necessary military factors and experience.

(j) Involvement in the international defence community provides an important means of access to extensive areas of new technology of great value in the non-defence field.

The brief lists at Annex D a number of international agreements concerned with defence research and development activities. The importance of continued access to this source of information and of participation in joint projects has already been mentioned. Another important dividend is that the advanced technological information acquired through these channels is often of considerable value to non-defence industries. For instance, the rapid advances in the electronics industry have resulted to a large extent from the pressure and urgency of defence needs. The same could be said of technology in the field of light alloy metallurgy.

(k) Civilian personnel are used when it is most economical and does not prejudice the maintenance and support of the operational forces.

Civilian personnel are employed in the Armed Forces Engineering sub-Branch when the maintenance and support of the operational forces is not prejudiced and when it is more economical to do so. The choice between civilian and military officers is governed by a number of factors which must be weighed carefully. On the one hand, civilian officers introduce an element of continuity which is difficult to achieve with military officers but, on the other

hand, civilian officers lacking field experience may tend to have a more remote knowledge of the vital operational aspects of service equipment. In addition, involvement in equipment engineering and development is an important aspect of career development for technical military officers. The civilian/military ratio at the officer level in the Engineering sub-Branch is about one to one, which appears to be an appropriate mix. Certain changes have recently been made in the policies governing the employment of civilian personnel in the Department of National Defence with a view to improving their career development pattern.

(m) New procedures for the initiation of equipment acquisition have been introduced with the aim of minimizing slippages and cost escalation.

Development projects everywhere have always been plagued with problems of cost escalation and slippage. When technology is being stretched and new concepts are being developed, an element of risk cannot be avoided. However, advantage has been taken of management consultants and it is hoped that the new procedures, described at Annexes L, M and N in the brief, for requirements definition, project formulation and implementation, together with the use of modern project planning and management techniques will lead to steady improvement in this regard. For all new projects, analysis and experimental work are undertaken, as necessary, to demonstrate feasibility, from the point of view of both technology and cost, before development is initiated.

(n) The test establishments and engineering standardization agencies perform a vitally important function in support of equipment acquisition regardless of the amount of development undertaken.

While some of the activities of the test establishments and engineering standardization agencies fall within the purview of your investigation, I should like to stress that they are not primarily concerned with the research and development functions of DND but with the much broader function of equipment acquisition. Whether we buy equipment from our allies, manufacture it under licence or develop it ourselves, these functions are vitally important to ensure that the equipment we acquire will meet the rigorous requirements for military service and provide maximum logistical economy.

RECOMMENDATIONS:

8. The brief presents to you three recommendations. The first relates to the need to undertake defence development projects in the overall national interests. I have already referred to the problems which surround the selection of development projects and it is clear that major projects cannot usually be based on Canadian military needs alone. The choice of development projects should, therefore, take into account other factors such as international co-operation, industrial capabilities, innovative capabilities and economic value, including export potential.

9. The second recommendation is a corollary which stresses the importance of retaining a strong military involvement in defence equipment development projects. Defence equipment usually makes use of the most advanced technology but, at the same time, the environmental, performance and reliability requirements are extremely stringent. In the desire to pursue projects of broad national interest, there is a tendency to underestimate the importance of unique military requirements. It is, therefore, recommended that this factor should be clearly recognized at all times during the consideration of the broader problem.

10. The third recommendation relates to the importance of the international defence community as an effective and proven means for the rapid exchange of information on advanced technology and its consequent value to the overall national technological capability.

11. In closing, I would like to say that I believe that in the past three years we have made great strides in improving our ability to formulate and manage our development activity within our financial and manpower constraints. With the relatively small size of our Forces and the consequently small quantity of each equipment that they require, and with the operational need to standardize our equipment with that of our allies, it is difficult, indeed, to find worthwhile major Canadian defence development projects. We are conscious of the economic aspects of defence and we are always on the look-out for attractive development projects which we can pursue jointly on a shared cost basis with our allies and with the

Department of Industry. We have already achieved modest success in these areas. The relatively new organization and procedures for handling development in the defence field, which appear promising, should be given an adequate trial period in which to mature and provide a reasonable assessment of their adequacy before being subjected to further change.

The Chairman: Thank you very much, Major-General Waldock. I think that from this point on we should address our questions to all members of the panel so as to avoid duplication. Before giving the floor to any member of the committee; I should like to ask a question that I wanted to ask this morning, but there was no time. I wonder, Dr. Uffen, if you can tell us what is the approximate proportion of research activities pursued by your institution which can be classified as secret.

Dr. R. J. Uffen, Chairman, Defence Research Board: Before answering your question would you let me say a word or two about what we mean by "classified information". The purpose of classifying, or making secret a category of investigation, is to deny any adversary, or potential adversary, information which would make it easier for him to take advantage of us—to deny him the opportunity of knowing whether we are adequately defended, well defended, or poorly defended, or what offensive capabilities we might have, and so on. This is why we have security regulations, and in our presentation so far I think most of you would I accept the fact that we have been extremely direct, but your very question, Mr. Chairman, is one that I am unable to answer.

The Chairman: You think that this proportion should remain secret?

Dr. Uffen: We must leave some things unanswered.

The Chairman: Yes. Before allowing Senator Grosart to ask his questions I would mention that this morning Senator Robichaud wished to ask a question, and I wonder if he would like to ask it now.

Senator Robichaud: It was a question regarding personnel. Questions were asked and answered this morning concerning the personnel of the Board, but, Dr. Uffen, in your recommendations at page 24 you say:

> (a) Increased salaries and soaring equipment costs within a fixed or declining budget would reduce the number and extent of projects. Sooner or later it will be necessary to either increase the funds available or close some research establishments.

This seems to indicate some fear or anticipation among the members of the Board that there is this possibility.

Now, in Annex V of your submission dealing with personnel statistics you show that as of July 1 of this year the total professional, technical, and other workers amounted to approximately 2,500, which is the entire staff of the Board. Can you tell us if in the last five or six years there has been an increase or a decrease in the total personnel, or if it has been more or less stable.

Dr. Uffen: I think a short answer is that it is more or less stable, but I think your question is best answered by my explaining that because of a financial ceiling on the Defence Department, which includes the Defence Research Board, we have been obliged to operate at slightly below our authorized establishment. We have been operating at about 600 professionals, when we are authorized to have 610. So, we are staying rather below the positions we would like to fill. I am not so familiar with the details of the non-professional support staff.

There is another point that might be appropriate here. Of course, we try to think ahead a few years, and that is why we have the planning staff in the headquarters, and at one time we sat down and performed an exercise in which we plotted and projected the probable future costs of our present programs, without any expansion, because of salary increases, inflation and what we call the sophistication cost in modern equipment—and this is going up very rapidly. If we project our likely operating budget, then we find that it is only a few years before the two intersect. In other words, we had better have some plan as to what to do in order to avoid this circumstance where we would have a well paid staff but no money or facilities to conduct work.

I do not think we are going to let that happen, but if our budget is kept constant, or even if it is allowed to increase by a cost of

living allowance, or an inflation allowance, and if the inflation allowance is smaller than the real amount, then we will have to plan to curtail our activities, and redistribute them. Sooner or later this would lead to closing a laboratory, or alternatively finding another use for it or moving the people somewhere else. My point here was that we have to anticipate this and not just have it happen.

Senator Bourget: I should like to ask Dr. L'Heureux if there is some difficulty in finding French-speaking scientists from our universities. In CARDE particularly, is the majority of the scientists French-speaking or English-speaking?

Dr. L'Heureux: At CARDE at the moment the professional staff is about 50 per cent French-speaking origin, but as I mentioned this morning, the number of those who are bilingual is much higher, it is about 75 per cent. The total establishment is about 85 French-speaking; that is taking the whole establishment, including the supporting staff.

Senator Bourget: I am interested particularly in research in respect of recruiting.

Dr. L'Heureux: We have now no great difficulty in professional recruiting for CARDE. We did in the past but we can now recruit almost any type of scientist we need. We still have a problem in recruiting French-speaking scientists in some of establishments. This, of course, depends on the social environment, not because of our laboratories.

Senator Bourget: Are you trying to help them financially in order to induce them to join your staff when they have completed their studies?

Dr. L'Heureux: We have a program of scholarships to assist our staff, but that is to get their Ph.D. if they have got a bachelor's degree; we have such programs. Normally there are between 15 and 20 professional staff taking postgraduate studies out of 600.

Senator Bourget: Looking at your table in which you show the sharing of expenses by regions, I notice that in Quebec between 30 per cent and 35 per cent of it is given to industry. In other regions the percentage is not so high as it is in Quebec. Is there a particular reason why the percentage is higher in the Quebec region than in the other regions?

Dr. L'Heureux: This depends on the industrial area. You will recall I did mention that our industrial grants were on roughly 50/50 basis, and these are normally with large companies. In the Montreal area or Toronto area there is a natural tendency for the industrial grants to be larger. That is why Quebec and Ontario have very large industrial grants compared with some of the other regions.

Senator Bourget: When one looks at Ontario for 1965-66, for instance, the intramural research is nearly $15 million, but only $3.5 million has been given to industry. There is a little but very important difference between that and what is given in the Quebec region to industry; in Ontario it is a little less. Mind you, I am not against it at all.

Dr. L'Heureux: Internally it is the laboratories. In Quebec there is the largest we have, which is CARDE. In Ontario there are four laboratories plus the headquarters. This makes our internal expenditure higher in Ontario than in Quebec. On industrial grants, it would appear that the big industries in the Montreal area are more interested in defence-oriented research than they are in the Toronto area.

Senator Bourget: You can do more research work here in Ottawa because there is the NRC. Would that be one of the reasons?

Dr. L'Heureux: With respect to industrial grants, we like to depend on the industrial capabilities of the region. These grants are chosen by a special committee and I am only supposing the reasons now. One supposes it is because in the Montreal region they have better projects and have asked for more support than certain other defence industries.

Senator Bourget: I am all for it.

Senator O'Leary (Carleton): Would General Waldock be prepared to say that because of the existence of the Defence Research Board we are getting a greater dollar value for what we spend on defence; if so, would he say he thinks the budget of the Defence Research Board might or should be increased?

General Waldock: The answer to the first question is undoubtedly Yes. In reply to the second question, I believe I would support the answer given by Dr. Uffen this morning that when you referred to an increase in a budget it depends what the context is. If the context is an increased proportion of the

defence budget then I would say No. If you are referring to the question of sums coming in from outside sources it is a rather different context.

The Chairman: From another department.

Senator O'Leary (Carleton): I do not know whether you have answered my first question. Do you think because of the existence of this board we are getting a greater dollar value for what we spend on defence?

General Waldock: Unquestionably, yes.

Senator Grosart: I too would like to address a question to General Waldock, which arises out of the article on the front page of the Montreal *Gazette* this morning. It is headed "Lucrative NATO Market Lost. Canadian Device Blocked by U.S." It is under the byline of Arthur Blakeley. Mr. Chairman, you saw me having lunch with Mr. Blakeley today and passed the remark that you hoped this did not mean there would be any leak! You also commented that a Canadian statesman of some repute once remarked that the way to make sure information was widespread was to mention it in the Cabinet and the way to insure secrecy was to have it announced in the Senate. However that may be, we are on the front page this morning. We were on some front pages last night, and I think we can thank some of our distinguished witnesses for the very valuable information which brought us there because the press regarded it as important enough to bring it to the attention of the Canadian public.

I hope I will not take up too much time if I read some of this article, because it is important. It deals with the statement made in the NRC. brief yesterday. Unless I am mistaken, there is a somewhat different version of the same project given in the submission we had today.

Parts of this article read as follows:

> An arbitrary political decision made in and by the United States cost Canada the "large and lucrative" NATO market for an ingenious counter-morter radar set designed and developed by the National Research Council and hailed as the world's best, according to informants here.
>
> The story of Canada's near-breakthrough in the military equipment field, in part at least, was contained in a special National Research Council report made public yesterday at a hearing of the Senate special committee on science policy.
>
> The report said that the Canadian equipment "to this day out-performs its rivals in the U.S.A. and U.K."

It goes on to quote the report, which appears on page 51 of the report, under the heading "Some Significant Projects". It then quotes a Government source—I am not saying this is NRC—and says

> that the NATO market was lost for the Canadian device because American authorities gave their backing to comparable, but inferior equipment, developed and built in the United States.

I direct the question to you, General Waldock, because the theme of this kind of problem seems to run through a great deal of the submission you made. For example, on page 6 you say:

> ...there is a tendency for the forces to prefer the purchase or manufacture under licence in Canada of equipment developed elsewhere.

He explains why and it is a very reasonable explanation. He says:

> .it is not always possible to support them from National Defence resources to meet Canadian defence needs alone.

Again if I may paraphrase, the General points out one of the reasons is that we have a small military establishment and we have the problem of lack of mass production facilities.

At page 10, if I may quote the General:

> .the most desirable development projects are those which, at the same time, meet Canadian defence needs, have high export potential and serve to expand the industrial technology base.

At page 11, the General says:

> ...if we are to retain access to the immense pool of allied scientific and technical information, it is necessary to make a reasonable contribution to it.

At page 17 he deals with the choice of development projects in Canada, and says:

> ...it is clear that major projects cannot usually be based on Canadian military needs alone. The choice of development

projects should, therefore, take into account other non-military factors such as international co-operation, industrial capabilities, innovative capabilities and economic value, including export potential.

And in the recommendations I read:

. . and with the operational need to standardize our equipment with that of our allies, it is difficult, indeed, to find worthwhile major Canadian development projects.

I will not go beyond that, but say that here apparently is a worthwhile Canadian development project, and I would ask the General if this is the same project that I find referred to in Annex T-1 of Part II of the submission of the Department of National Defence to the Special Committee on Science Policy, etcetera, Armed Forces Activities. Is that the same project? That is the same name, Counter Mortar Radar. Is that the same program?

General Waldock: Yes. I have not read that article, but I would suggest it is the same program, certainly.

Senator Grosart: First of all, is this suggestion true, that the American authorities ultimately picked inferior equipment, in view of the statement you make here, about which a parallel was made by the NRC, in which you say:

(It) is now in service with the Canadian Forces. It materially exceeds the stated military requirements it was built to satisfy and is the only such radar in the world today which incorporates an effective polarizer to permit operation in rain, snow and fog. In these respects it is significantly more effective than its U.S. and British counterparts.

You say this is the same thing?

The brief states:

Two AN/MPQ-501 radars were sold; one each to Germany and Italy. These were subjected to trials and were well received by the military staffs.

The AN/MPQ-501 Counter Mortar Radar development has now been terminated in conjunction with the introduction into service of the equipment. In the light of significant changes in state-of-the-art and military requirements, no further development is planned in this area.

Are we dealing with the same thing? Is the statement accredited to a Government source approved and, if so, what do we do about it?

General Waldock: Senator, I cannot tell you, I do not think anybody else can tell you, in simple words that this U.S. equipment is better or worse than ours. I am perfectly certain that in some respects it is probably better and that in some it is not as good, but I do not have this detail with me. There is a natural tendency on the part of all countries to wish to procure the equipment they have developed themselves; and in the early days following the war, World War II, when we began to get into our agreements with our various allies aimed at co-operative development, we had a major snag we had to overcome, and I do not suppose we have completely overcome it now. It was called the N.I.H. factor—"Nor invented here".

Also from the viewpoint of the U.S. economy, undoubtedly they are going to promote their own equipment, even if it is not as good as ours; and I am not sure that we would not do the same thing in similar circumstances. I do not think the difference in performance of the equipment is more than marginal, to the best of my recollection.

Senator Grosart: That does not seem to be the statement here. The statement here, if I read it correctly, is quite to the contrary. The emphasis is on the fact of its comparative superiority to any similar weapons system developed elsewhere. This is why I raise the question. If it were marginal, I would not raise the question.

General Waldock: Certainly, we are very satisfied with our own. It more than met our own requirements, and we put it into production, and we have it in service.

When you get into the question of persuading the Americans to adopt it, you are really in the area of the International Programs Branch of the Department of Industry and, frankly, I am not aware of the details of that particular project; and what happened when we tried to sell it to the United States, I do not know. I do know that they had a comparable development, and I think it would be natural that they would tend to favour their own development, even if it were not as good as ours.

Dr. L'Heureux: I do not know what the article says, and the article may not be complete, but as to effectiveness versus cost of

equipment, it may not be as good as the other one, but it is perhaps much cheaper.

Senator Grosart: My recollection is that in neither brief is there a direct reference to cost, but a general statement of superiority would imply that cost was one of the factors in the superiority, or there would be no qualitative basis of comparison.

The Chairman: I have just been told that coffee is about to be served. It would be an appropriate time to adjourn—and this might give our guests time to read the article.

A short recess.

(Upon resuming)

Senator MacKenzie: I have a supplementary question, Mr. Chairman, if it is in order to ask it.

As I remember it, just after World War II there was an effort to achieve standardization in respect of small arms and ammunition. Did anything come of that? My impression is that while there was a sort of general agreement that a certain rifle was the best, it was not acceptable to all of the nations involved.

General Waldock: Yes, senator, somewhere in the middle 1950s Canada, the United States, Britain, and Australia, and subsequently NATO itself—all of NATO—standardized on small arms ammunition.

Senator MacKenzie: Yes, I remember the ammunition.

General Waldock: Yes, both for the rifle and the pistol, the 9 millimetre pistol.

Senator MacKenzie: And the machine gun?

General Waldock: Yes, the light machine gun. As far as small arms weapons are concerned, Canada standardized—this is well known, I think—on the FN rifle, and Britain, Australia, and Belgium also had it.

Senator MacKenzie: Yes, that was a Belgian rifle.

General Waldock: Yes. The United States went along with that standardization. There were continuous conferences on the subject. The United States went right along, but they kept their option open between the FN rifle and a rifle of their own development which, I believe, is the M-14. They finally decided to adopt their own, so we did not standardize the rifle with the United States. This was quite a tough decision on their part. The option remained open for a long time with the United States, and they eventually decided to adopt their own.

Senator MacKenzie: I would hate to say that this was rather typical of them, but I am inclined to believe it is. That is my feeling, by the way, rather than knowledge.

The Chairman: Would you know the date when the project referred to by Senator Grosart was abandoned?

General Waldock: Mr. Chairman, I do not think anything was abandoned. We adopted ours, and they adopted theirs.

The Chairman: But when was that decision made, do you know?

General Waldock: I would think about 1960.

Dr. Uffen: 1961.

The Chairman: 1961?

General Waldock: Yes.

Senator Grosart: General, the statement here that refers to that is:

> The AN/MPQ-501 Counter Mortar Radar development has now been terminated...

General Waldock: It has been terminated because it has gone into production. This is the way we like to terminate them, senator.

Senator Grosart: I may be wrong, but it says:

> ...In the light of significant changes in state-of-the-art and military requirements, no further development is planned in this area.

General Waldock: I think what we are saying there is that we are not about to develop additional equipment, but that was a successful development, from our viewpoint. It went right through the classic stages of testing and evaluation, and it performed and met the requirements, and then went into production.

Senator Grosart: And it is now in service in our armed forces?

General Waldock: Yes.

Senator Grosart: The cost, I think, was about \$5 million, according to the statement here.

General Waldock: Yes.

Senator Grosart: So, here is a case of where an expenditure of $5 million has enabled an R and D project to find an adequate market with the Canadian Forces alone; is that correct?

General Waldock: Yes, that is correct. We would have preferred to see it adopted by other countries, because that would have increased the production run and reduced the unit cost.

Senator Grosart: Was there consultation finally between our allies regarding this production?

General Waldock: All the way through, between the tripartite countries—Britain, America and Canada—and subsequent to our adoption of it it was offered to the NATO countries. In fact, I believe the brief says that two were sold to other countries for evaluation.

Senator Grosart: Yes, Germany and Italy?

General Waldock: Yes.

The Chairman: But these negotiations would have been carried on by the Department of Defence Production?

General Waldock: Yes, by the Department of Defence Production at that time, and the Department of Industry at this time.

Senator Grosart: Is it satisfactory to have a civilian agency of Government take over a development in the military area and conducted by a military establishment, and assume responsibility for selling? I presume that selling from a military man to a military man would be more effective. Are you satisfied with this arrangement?

General Waldock: Well, from a military viewpoint, senator, I do not think—it is certainly not our departmental policy at this moment to be in the sales game. It is our policy to support the efforts of a department which is concerned with promoting the Canadian economy. I think most of us would have mixed feelings on this. We do not want to get into the international arms racket. At the same time we do want to reduce the unit cost of our equipment. So, we have mixed feelings.

Senator Grosart: Who sells American weaponry? How do they sell it?

General Waldock: It is sold from the Department of Defence, and there is a senior official, who I believe is at just under the assistant secretary level if not at the assistant secretary level, who co-ordinates and handles all of this.

Senator Grosart: Are they highly successful compared to us in selling military hardware abroad? That, perhaps, is not a fair question.

General Waldock: That is a question I think you will have to direct to the Department of Industry. They are certainly not unsuccessful.

Senator Hays: General, is this decentralization, with many establishments across Canada, costly, or would it be more efficient to have a centralization of these various research programs?

General Waldock: You are really referring now to the Defence Research establishments, because I am only concerned with three testing and evaluation establishments, and they are in fact—one is in Montreal, and the other two are in Ottawa. I think the question is one really for Dr. Uffen.

Dr. Uffen: I think it might cost more if we were centralized, but I have not any real justification for saying this. If you centralize in the Montreal or Toronto areas, or somewhere where the cost of living is extremely high, and land rentals and so on are high—if you were to operate these establishments in a high cost area then the costs might be raised considerably. Some of our laboratories are in areas where costs are low. But, I am unable to give you a precise answer.

Senator MacKenzie: Three of your laboratories are pretty well all where it is necessary to have them. There is one on the Atlantic coast, one at Esquimalt, and one in Alberta. They could not be centralized effectively here because of the nature of the work that is being done.

Dr. Uffen: The odd thing is that some very useful anti-submarine warfare work was done in the Ottawa River.

Senator MacKenzie: That does not surprise me.

The Chairman: Is that why the river is polluted?

Dr. Uffen: It was up above the pollution.

Senator Grosart: General, may I ask you one more question on the counter mortar radar. It is rather interesting to note that both the NRC and our present witnesses have responded in the same way to the question in our guidelines which asked what was the present case histories of what you consider to be the most significant completed projects of the last five years. Whose project was this—the NRC's or yours?

General Waldock: It was funded largely by the Department of National Defence, but the work—certainly all of the early work right up to the point of the developmental prototype was done at the National Research Council. This grew out of the work they had done during the war and before the Defence Research Board was formed. It was a natural continuation of the activity they had been engaged in.

Senator Grosart: Does it happen very ofteen that NRC initiates a project that moves into the military sphere?

General Waldock: Only in rather unusual circumstances. This was a legacy from World War II when the Defence Research Board did not exist, and when the National Research Council did a fair amount of defence research work. If we wished to initiate a similar project now we would go straight to the Defence Research Board and leave it to them whether they conducted it in their own establishments or elsewhere.

Senator Grosart: How does their very extensive work in aeronautical research move into your orbit?

General Waldock: I do not know whether Dr. Uffen would prefer to comment on this.

Dr. Uffen: I am sorry, I cannot make very many useful observations. I think Dr. L'Heureux would be more appropriate to answer this.

Dr. L'Heureux: Going back in history, the National Aeronautical Establishment nearly became one of the Defence Research Board establishments, but after the cancellation of the C.F.105 a decision was reached that it would be preferable if this laboratory went to the National Research Council, but there was an agreement at that time that the research work in aeronautics would be done by the National Aeronautical Establishment, both civil and defence. This is how the defence research work in aeronautics comes to be done by the National Aeronautical Establishment.

Senator Grosart: How was this decision related to the cancellation of the Arrow development?

Dr. L'Heureux: Before that time the military expenditures in aeronautics were much higher than the civil, but after this cancellation it was felt that the civil side would get more support.

The Chairman: We presumed there would never be a C.F.110 I suppose.

Senator Grosart: That is getting too near the area of politics so I will refrain from comment.

Senator Thompson: I notice the General suggests that in development one of the desirable objectives is that it should not only be useful in the broad military field, but should also be useful perhaps to the overall national technological capacity.

I suggest that one of the peculiarities of our nation is the climate. I am thinking particularly of the winter and transportation, which would certainly pertain to the effectiveness of the military. Putting it very simply, it seems to me that the bombardier and skidoo were developed in garages by people with very little revenue, yet they have been of great use to both the military and civilian populations. Could you give me concrete examples of your development programs which have helped our civilian transportation, particularly during the winter?

General Waldock: I can give you one very concrete example. In the 1950s we funded a development project for an over-snow vehicle, an operational vehicle, which was called the "Rat". The actual development was carried out in Canadair. A quantity of these was procured by the forces. It was not a cheap vehicle by the time it was finished. It was the first in its field in the sense that it consisted of a prime mover and behind it had a load-carrying vehicle. They were articulated; they could twist independently and the drive was conveyed through this articulated joint.

Subsequent to that, and based on that same design, Canadair developed, under Department of Industry auspices, with considerable support from National Defence, a larger vehicle known as the Dynatrack. This

is a pretty successful development. It is now in the stage of being evaluated. It is being evaluated by the U.S. Army which has in fact ordered a small quantity in advance of their evaluation. I think at this point the Canadian forces are very interested in it too. We have a requirement for that kind of vehicle and we are waiting to see whether or not it goes into large scale production for the U.S. forces, in which case the unit cost will come down to something we can stand. If there is not a large market for it elsewhere outside of Canada, once again our small requirements will put the unit price up, probably beyond our means.

Senator Grosart: Is the NAVAID project an example of rather better luck in marketing than the one we were talking about?

General Waldock: I think we were there first with an original idea. We had no competition to speak of.

Senator Grosart: You sold it to the United States, I believe.

General Waldock: No, not to the United States, as far as I know.

Senator Grosart: I thought you did. Perhaps not.

General Waldock: I am sure it has been evaluated by them, or is being evaluated by them.

Senator Grosart: It is in Appendix P:

> The system is now being produced in Canada for use by British and U.S. forces.

General Waldock: That is correct. Once again you are out of my field here. Yes, that is correct, we have sold to the United States, the United Kingdom and various NATO countries and Australia for trial and evaluation. The export potential of this is assessed as being very good. There is no doubt in my mind that this is a project which has paid off economically, and we were there first with a good idea.

Senator Grosart: Would the SKOP project be in that class?

General Waldock: Yes, we had the idea. Perhaps we did not pursue it, as the brief indicates, with quite as much enthusiasm as the British. It hit us at a time when our operational requirements were a little undecided in this area: we were going through quite a major revision and did not jump in with both feet. It is a relatively small project I should say. It is not of the same kind of complexity as some of the other things we have discussed.

Senator Grosart: You have made the point that it is in the smaller weapons area that we are most likely to develop something which will have a more universal use amongst our allies.

General Waldock: This consisted essentially of the basic idea.

Senator Grosart: This was the shelter.

General Waldock: Yes. One has a sheet of polyethelene and by putting some small support under it and covering it with earth one can support an enormous weight. For example, a vehicle can pass over it without hurting the people inside. It is a simple idea, but also very easy to copy.

Senator Grosart: What is the situation with the "beartrap"?

General Waldock: I think we have this one to ourselves at the moment. Again we are rather getting into the Department of Industry field. I know there is a strong interest in this from other countries. We have certainly gone for it completely. It is a unique Canadian development, and a good one.

Senator Grosart: So there is a pretty substantial area in which we can hope in the future to develop a larger market for these R and D projects under your control?

General Waldock: I think so, yes.

Senator MacKenzie: This has proved true in the case of those two working planes, the Otter and the other one.

General Waldock: Yes. They have certainly been very successful programs. Once again I am a little out of my field here and I am not quite sure how much defence contributed to them.

Senator MacKenzie: I was not thinking of that. I was thinking in terms of a Canadian project.

General Waldock: Undoubtedly a most successful Canadian project, and we use them.

Senator MacKenzie: Successful in the international market.

The Chairman: So far as defence research and development is concerned, would you say that in general the international division of labour has improved or worsened over recent years?

General Waldock: I think undoubtedly it has improved, but I believe it has a long way to go.

The Chairman: What about in your field of research, Dr. Uffen?

Dr. Uffen: I am sorry, but I have too short a time interval to be able to make a comparison whether it is going one way or the other, in my own experience.

Dr. L'Heureux: I would say it is about the same.

Senator MacKenzie: Did not your department have a good deal to do with these operational planes referred to?

Dr. Uffen: I was thinking about the de Havilland Beaver, the Otter, the Buffalo and so on. The de Havilland company has been one of the companies which has taken advantage of the Defence Industrial Research Program to a very great extent. While it is difficult to identify specific things that happened, they have told us in their reports that the engineering development of those three aircraft was very substantially aided by the DIR program.

Senator MacKenzie: This is expected to follow in respect of that small jet engine?

Dr. Uffen: I do not know.

Senator MacKenzie: We hope!

Senator Grosart: General, you have mentioned the NIH factor—"not invented here". My recollection is you referred to it in more or less past terms. Is it still the overriding factor in these decisions?

General Waldock: I hope not, senator. I believe that all countries nowadays are learning that it is difficult to go alone in this field, and even the American resources are stretched to the limit, and the prospects for co-operative development are improving because of the enormous costs involved. I think countries are being forced to look more and more to co-operative development rather than proceeding on a purely unilateral basis which is becoming beyond their means. This, in turn, seems to overcome the NIH factor.

Senator Grosart: Does this bring us into this field of the defence production sharing agreements?

General Waldock: Yes, very much. This is a line of country, when you have the Department of Industry in front of you, with which they will be able to cope with much more competence than I can. They are very much in this area.

Senator Grosart: Are these nation-to-nation agreements? I have forgotten.

General Waldock: There are broad agreements and individual agreements on individual equipment, depending on what you are talking about.

Senator Grosart: Do they specify percentages?

General Waldock: I cannot tell you, senator. I am right out of my league now.

Senator Thompson: Following Senator MacKenzie's question about the Otter and Beaver, again coming back to the transportation question, in the Arctic, what kind of studies are you doing as far as the servicing of aircraft hangars and making them adaptable to the climate of the Arctic is concerned and with regard to the examination of the kind of planes? I know there is a Japanese plane now being used, the YS-11. In those three areas what are you people doing?

General Waldock: I cannot tell you specifically what we are doing about hangars, but when it comes to air field clearance ice and snow removal, we are considered to be quite a leader in the expertise involved in this, and we have rather informal co-operative arrangements with Sweden and the United States in this area. This is one of the major problems in relation to aircraft, the problem of keeping the runways clear, and so on. I cannot tell you exactly what we are doing in the field of hangars.

Senator Thompson: I am thinking of the whole problem of servicing in sub-zero weather.

General Waldock: We are in the field of oils and lubricants. We stress the cold end of the temperature range all the time in terms of oils, lubricants, cold starting, batteries and so on. We have to operate in these fields, and we have a pretty well continuing program, one that goes almost without saying.

The Chairman: At the research level, I presume that NRC would be the most active agency in this field.

General Waldock: Yes.

Senator Thompson: My question is this, is the NRC doing studies of this type of thing? This seems to me to be so pertinent to the development of our North. We have to innovate so that we can combat the cold in the North with respect to transportation.

Dr. L'Heureux: We do have some laboratories—and so does the National Research Council—working on lubricants and greases.

Senator Thompson: As far as the type of plane with quick assent and this type of thing, who would be studying that—is there anyone?

General Waldock: NAE is quite active in this field. It is a leading authority on de-icing of helicopter blades. You may have seen the big spray rig they have on the way out to the airport. I do not know of anybody doing it and co-ordinating it in one branch, except NAE itself. But it is such an everyday problem with us that we could not operate without continually considering it.

Senator Thompson: There is a Government research department that is constantly analyzing these problems?

General Waldock: Yes, and not DND alone. The National Research Council is, and I am sure that Energy, Mine and Resources and in the field very strongly.

The Chairman: Are you working in close liaison, so as not only to avoid undesirable duplication but also to fill possible gaps?

General Waldock: I think very definitely. There is an interdepartmental Fuels and Lubricants Committee. For battery research we rely on the Defence Research Board.

Dr. L'Heureux: We work closely also with NRC on lubricants, greases, and so on.

Senator Thompson: Having been in Churchill, I think if we could tackle that kind of thing it would be useful both for military and civilian uses—the whole approach not only to lubricants but hangars, and perhaps the design of hangars, for planes in cold weather, the whole variety of problems that have to be faced. I think that would be of great benefit to us.

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Senator Yuzyk: This is regarding the unification of the armed forces. Is it expected it will contribute to the improvement of R and D? Have certain arrangements been made which will make it possible to do better work?

Dr. Uffen: I think it has already happened from our point of view. You could ask for the Armed Forces' point of view. We now deal with one agency instead of three, and we have a committee called the DARPG—the Development and Associated Research Policy Group—which is chaired by the Chief of Technical Services and has representatives of both the Armed Forces and the Defence Research Board. This is the co-ordinating group for the civilian-military interplay. It is just one group to deal with and, as far as I know, things are going along a lot better now than previously. It is about 2½ years old.

Senator Yuzyk: You should be able to plan bigger projects in this case, with the unified forces?

Dr. Uffen: Yes.

Senator Yuzyk: Are you able to convince the Government or the minister in this case that funds, extra funds are necessary for certain developments?

Dr. Uffen: I think that is a function of how big a proposition it is. We are fairly successful up to about $2 million or $3 million.

Senator Grosart: Is the total percentage of defence expenditures going into military hardware increasing since unification or integration?

General Waldock: I think it is pretty constant.

Senator Grosart: My understanding was that this was one of the advantages to be gained from integration. I do not want to be political; I am just asking this as a factual question.

General Waldock: The answer, as has been stated elsewhere, lies in the fact we have been victims of a rather high rate of increase in the cost of living, which has not permitted delivery of the dividends we had hoped for from integration.

I might refer you to my Chart IV, which is my own particular branch, and you will see what I think is a pretty good example of integration. We have not tried to mix the engineering of ships with the engineering of

aircraft or automotive vehicles, because these are not integrated in industry or anywhere, bu we have one engineering group looking after all the aircraft, no matter who is using them—the land forces, the air forces or the fleet. We have one group looking after the engineering of all the vehicles. We have considerable commonality in the field of communications and electronics engineering. We have one quality-control organization for the whole lot. There has been a saving of personnel—in my particular area, in the region of 40 per cent.

Senator Hays: Mr. Chairman, Dr. Shebeski in Winnipeg has perfected a plastic substance that can be spread on grain. With this plastic covering material on the grain he can determine exactly when it will grow. If this seed could be distributed during the winter months on the snow, and then this plastic substance would deteriorate at the proper time in April when you would ordinarily seed, it might prove to be of great benefit.

I have spoken to quite a few people about this. In New Zealand, which I have visited many times, they are now spreading fertilizer by aircraft, and using mostly Canadian planes and Canadian pilots. One pilot can fertilize about a thousand acres a day.

Would you be the right people to go to in so far as the development of machinery like this is concerned? This could mean, in the seeding of crops, $250 million a year.

Dr. Uffen: Shall I try to answer this?

General Waldock: Yes.

Dr. Uffen: We could do it. I think we have the facilities. We have the aircraft, and the Suffield experimental station would be a place where we could do it, but it would not be a proper thing for us to do in terms of the National Defence Act. If someone said that they really wanted it and were prepared to use a financial encumbrance to provide the money and the wherewithal, we would have to look at it, and we would be glad to, but my responsibility is to see that it did not disturb the priorities in defence. It sounds like a magnificent idea.

Senator Hays: You would then take this to the NRC?

Dr. Uffen: It would make more sense to go to the National Aeronautics establishment of the NRC than to involve the Defence Department in such a project.

Senator Hays: It would be in the field of research somewhere. Someone would have to produce a machine that could carry 700 or 800 bushels of seed, and travel at a speed of 80 miles an hour. They do such things very efficiently in New Zealand.

Dr. Uffen: Dr. Shebeski was a member of the National Research Council for three years when I was there, and he would be quite familiar with the avenues available to him.

Senator Grosart: But you would not be concerned unless a military application could be indicated?

Dr. Uffen: I think it would be outside our normal terms of reference. We have done this before and, of course, would do it again in the national interest, but it would have to be recognized as being outside the proper sphere of activity of the Department of National Defence. I know I would have to work very long and hard with our minister and deputy minister in order to convince them that we should spend any of our funds on it.

Senator Thompson: You have had survival courses in the Arctic, and you have had medical doctors and others examining the problems encountered. How is the information you have obtained translated over to the Department of Indian Affairs, for example, so that it may be of benefit to people in the North?

General Waldock: I cannot answer for the medical side at all. I do not know what the arrangements are. We have had a fair degree of involvement in Arctic clothing, and generally coping with the environment in terms of living up there. So far as the equipment is concerned, and the clothing, and so on, as distinct from the medical side of the argument, I think we are accepted as the normal authority in Canada, and all departments consult us on this. Other countries consult us also.

Senator Thompson: Suppose a private industry was developing a mining area such as that at Thompson, for example. Would you advise it concerning architecture, and everything concerned with building comfortable habitations there?

General Waldock: We are not doing it for industry in that context, but we would certainly be prepared to do it if we were approached. But, I think industry would go

first to the National Research Council, because they are particularly active in that area of building research. Certainly we would be happy to give our information in this area to anybody who requests it. It is not of a particularly classified nature.

Senator Thompson: Well, do we know that the information you have derived, and which is non-classified, is being used by both industry and government bodies concerned with the North?

General Waldock: I think this is more in your area than mine, Dr. L'Heureux.

Dr. L'Heureux: All of our unclassified reports are available to all Government departments, universities, and industry.

Senator Thompson: Do you know if they are used?

Dr. L'Heureux: Yes, in a number of cases they do come to us when they have a specific interest, and where we can we advise them.

Senator Yuzyk: Who takes out the patents?

Dr. L'Heureux: If it was the result of work that we did then we would take out the patent.

Senator Yuzyk: You take out the patent yourself?

Dr. L'Heureux: Yes.

—Senator Cameron then took the Chair.

The Acting Chairman: I might just explain that Senator Lamontagne has had to leave in order to attend another meeting, so I am taking his place while he is away.

Are there any further questions?

General Waldock: I am informed that the Department of Northern Affairs has a co-ordinating committee on Arctic development, to which we contribute.

Senator MacKenzie: Mr. Acting Chairman, if there are no further questions I should like, on behalf of us all, to thank those who have appeared today for the patient way in which they have answered our questions, even when they were embarrassing. We are very grateful to them.

The Acting Chairman: Thank you very much.

The committee adjourned.

APPENDIX 3

SUBMISSION OF THE DEPARTMENT OF NATIONAL DEFENCE

TO THE

SPECIAL COMMITTEE ON SCIENCE POLICY

OF THE

SENATE OF CANADA

PART I – DEFENCE RESEARCH BOARD ACTIVITIES

Report No. DR 191

October 1968
OTTAWA

68-339

FOREWORD

1. Within the Department of National Defence there are two main agencies that are concerned with aspects of scientific research and development falling within the order of reference of the Special Committee on Science Policy of the Senate of Canada. These are the Defence Research Board and the Chief of Technical Services Branch of the Canadian Armed Forces. Both these organizations are major parts of Canada's scientific and technological community, spending between them on research and development approximately $80 million annually and employing approximately 700 civilian and 200 military professional engineers and scientists.

2. Because of the complexities of identifying the various aspects of R and D in these two large organizations, one primarily civilian and the other primarily military, this submission is presented in two parts:

Part I - Defence Research Board Activities;

Part II - Armed Forces Activities.

As will be found in the detailed presentation, these two agencies work closely together. The format required by the Senate Committee's "Guidelines for Submission of Briefs and Participation in Hearings — Specific guidance for agencies of the Federal Government", has been followed in both cases. Each part has its own Table of Contents, and Summary.

3. A few difficulties existed in providing some of the detailed information requested, partly because of changes accompanying unification of the Armed Forces and partly because scientific activities are not always isolated and recognizable but undertaken within a department whose primary concern is national defence. However, this brief is probably the most detailed and accurate unclassified assessment of *scientific* policies, organization, personnel, expenditures, projects and activities ever made for the Department of National Defence.

4. At the request of the Deputy Minister of National Defence, the Chairman of the Defence Research Board has undertaken to submit the brief with assistance from the Chief of Technical Services.

PART I

DEFENCE RESEARCH BOARD ACTIVITIES

CONTENTS

SUMMARY OF PART I

This part of the Submission deals with the activities of the Defence Research Board that are, in essence, concerned with providing scientific advice to the Minister of National Defence and support to the Canadian Armed Forces. The organizations of the DRB Headquarters and of the various Research Establishments are described, including channels of communication within DND, with other Federal agencies, with industry, universities and foreign agencies (ANNEX I).

The statutory functions and powers of DRB are stated and the evolution of organizational policies and principles are outlined in ANNEX II. Special attention is given to the DRB responsibilities vis-a-vis other agencies; the history of the Research Satellite Program; Defence Scientific Information Service; the methods used to relate projects to defence needs and to assign priorities; and the processes by which the operational effectiveness is reviewed and revised. The policies governing intramural program selection, the University Grants Program and the Defence Industrial Research program are detailed in ANNEX VII.

The functions of the Selection Committee of the DRB are presented along with personnel policies which have been evolved. DRB is a "Separate Employer" under the Public Service Staff Relations Act. Statistics are given of the current establishment and manpower strength with details of the levels of education and experience of the professional staff, their bilingual competence and rates of turnover (see ANNEX III and ANNEX IV).

Data are presented for both capital and operating expenditures for the period 1963-68 in several regions of Canada. Defence problems require scientific activities in many geographical environments (see ANNEX IV). Data are also given for the period 1963-74 (actual and projected) by function, by scientific discipline and by area of application, (see ANNEX VII).

The following main conclusions are drawn:

(a) DRB has played a very large role in Canada's scientific activities. In the early days it was the major supporter of medical research. From 1962-67 DRB sponsored approximately 500 university projects costing $13,100,000. No secret work is sponsored under the University Grants Program.

(b) Because of the creation of new scientific agencies and the rapid growth of civilian research, the relative impact of DRB's activities is decreasing.

(c) Research projects originating in DRB establishments or sponsored by DRB are known to have given rise to Canadian production orders close to $200,000,000, a large proportion of which has been export trade. This is equivalent to the costs of the Board's activities for several years, entirely apart from its contribution to national security. From 1962-67 the Defence Industrial Research program sponsored 166 projects with DIR funding of $28,300,000 and equal amount from industry. Several new industrial operations have arisen as a result of DRB's programs and support.

(d) DRB's expenditure of approximately $50 million per year is spread across Canada but 75% is spent in Ontario and Quebec. In 1967-68 approximately 70% was spent on intramural projects, 6% in universities and 24% in industry (grants and contracts).

(e) DRB has played the leading role in research satellite development in Canada and has made it possible for Canada to undertake to develop its own civilian satellite communication system.

(f) From 1962-67 the staff published 1600 articles in scientific journals and books and 840 internal technical reports. Patent applications were filed on 222 discoveries and 159 have been issued. The Defence Scientific Information Service acquires, catalogues and disseminates between 30,000 and 40,000 documents annually, most of which are classified and of foreign origin.

(g) DRB has been able to attract first-class scientists and engineers because of first-class working conditions, personnel policies and equipment and exciting projects in the forefront of scientific research. Of the professional staff, 34% have Masters degrees and 26% have Doctorates. The turn-over rate is low, approximately 5% per year, and the "average professional" has been with DRB for 13 years and is 44 years of age. (DRB is 20 years old). Twenty-four per cent have had industrial experience; 26% received part of their education abroad, and 16% are in primarily executive or administrative positions.

(h) The average age of 44 years is high for a research organization and there is a tendency for the staff to become concerned with the problems of maturity, i.e., concern for job security, promotion, status, and pension plans. Under present restrictions this average age is likely to increase which is an unhealthy trend in a research organization. There are a limited number of senior executive positions and older men who fail to occupy such positions sometimes become discouraged. It is unlikely that a Canadian scientist under 40 years of age will have had military experience, so there is a probability that problems of National Defence will be unknown to or disregarded by the oncoming generation of young scientists unless they spend a part of their career in a defence research establishment.

(i) DRB has just completed a reorganization. Through the introduction of program budgeting; emphasis on planning, operations research and analysis; and the creation of the posts of Scientific Assistants to the senior military officers, DRB is better able to adjust to the needs of the unified Canadian Armed Forces, and changing defence and foreign policies.

(j) The separation of the responsibility for research and preliminary development (DRB) from that for development (CTS Branch of the Armed Forces and DOI) and procurement (DDP) presents some problems. This division of responsibility for defence R & D between four agencies in three Government departments has been unusual in the Western Alliance.

(k) The Chairman, DRB, advised by the members of the Defence Research Board and supported by the activities of the advisory panels and permanent staff of its headquarters, its research establishments and its liaison network, provides a necessary civilian scientific contribution to the deliberations of the Defence Council.

The following recommendations are made:

(1) Increased salaries and soaring equipment costs within a fixed or declining budget would reduce the number and extent of projects. Sooner or later it would be necessary to either increase the funds available or close some research establishments. The local economic and social implications of staff lay-offs and laboratory closures must be anticipated. Consideration should be given to the possibility of "forced attrition" by introducing incentives for early retirement and by transfers to other research agencies.

(2) It would be desirable to improve the "portability" of pension plans with industry and universities.

(3) Sudden major changes in Government policy and funds should take into account the lead time required to make corresponding changes in research programs. No major changes in DRB's roles and objectives are being planned but may arise, nevertheless, as a result of major changes in policies regarding science or defence.

RESEARCH ACTIVITIES

INTRODUCTION

1. This part of the submission deals with the activities of the Defence Research Board that are concerned with providing scientific advice to the Minister of National Defence; research requirements of the Canadian Armed Forces; contributions to collective defence research efforts of our allies; and the support of basic research of defence interest in Canadian universities and applied research of defence interest in Canadian industry.

2. The Defence Research Board was established in 1947 by an amendment to the National Defence Act. Its initial laboratory facilities and staff originated in the National Research Council and the Canadian Armed Forces. It is a mission oriented research organization and consequently many of its policies, practices and organizational structures reflect the need to mesh with military structures.

3. Since its inception the Defence Research Board has been independent of the Civil Service Commission (now the Public Service Commission) and has developed its own personnel policies suited to the needs of a research organization. More recently the Board was given separate employer status under the Public Service Staff Relations Act 1967. In practical terms the Defence Research Board has the same responsibilities for employment and staffing as the Public Service Commission, the responsibilities for personnel administration exercised by the Treasury Board for the Public Service generally, and for the appropriate machinery for collective bargaining. The Defence Research Board exercises the responsibility for collective bargaining through the activities of two committees — the Bargaining Policy Committee and the Bargaining Committee in consultation with the Treasury Board staff.

4. As will be seen in the accompanying Annexes I — IX, the Defence Research Board has for twenty years played a major role in advancing fundamental scientific discovery, the application of new scientific knowledge and principles to the needs of national security and in the technological exploitation of these in the national interest with a consequent major impact on industrial research and development in Canada.

ANNEX I — DEFENCE RESEARCH BOARD ORGANIZATION

GENERAL

1. The Defence Research Board operates under Part III of the National Defence Act which provides that "there shall be a Defence Research Board, which shall carry out such duties in connection with research relating to the defence of Canada and development of or improvements in materiel as the Minister may assign to it, and shall advise the Minister on all matters relating to scientific, technical and other research and development that in its opinion may affect national defence".

2. It consists of a Chairman and a Vice-Chairman appointed by the Governor in Council and

(i) the President of the National Research Council of Canada;

(ii) the Deputy Minister of National Defence;

(iii) such members as may be appointed by the Minister, as ex officio members representing the Canadian Forces; and

(iv) such additional members representative of universities, industry and other research interests as the Governor in Council appoints.

3. The current membership is as follows:

Chairman	- Dr. R.J. Uffen.
Vice-Chairman	- Dr. L.J. L'Heureux.
Ex Officio Members	- Dr. W.G. Schneider, President of the National Research Council.
	- Mr. E.B. Armstrong, Deputy Minister of National Defence.
	- Gen. J.V. Allard, Chief of the Defence Staff.
	- Lt-Gen. F.R. Sharp, Vice-Chief of the Defence Staff.
	- Lt-Gen. L.G.C. Lilley, Chief of Technical Services.

Members by Appointment

Dr. W.G. Bigelow	- Associate Professor of Surgery, University of Toronto and Senior Surgeon and Head, Division of Cardiovascular Surgery, Toronto General Hospital.
Dr. H.E. Duckworth	- Vice President (Academic), University of Manitoba.
Mr. J.D. Houlding*	- President and Director, RCA Victor Company Limited.
Mr. G.W. Hunter	- Deputy Minister of Defence Production.
Dr. H.H. Kerr	- Chairman, Ontario Council of Regents for Colleges of Applied Arts and Technology.
Dr. A.B. Van Cleave	- Chairman, Division of Natural Science, University of Saskatchewan.
Prof. M. L'Abbé	- Vice-Rector, University of Montreal.
Prof. N. LeBlanc	- Vice-Rector of Laval University.

4. The Chairman is the Chief Executive Officer of the Board and, under the direction of the Minister and in accordance with policies approved by the Board, is responsible for directing the staff of the Board, exercising general control of the business of the Board, supervising the work directed to be carried out by the Board, directing the organization, administration and operation of the defence research establishments of the Board and performing such other duties as the Minister may assign to him.

5. As Scientific Adviser to the Minister of National Defence, the Chairman of the Defence Research Board is a member of the Defence Council and is thus able to bring to bear on major policy and plans all the scientific and technical knowledge that is available.

6. The Vice-Chairman acts as Chairman in the absence of the Chairman and performs such other duties as the Chairman may assign to him. These include representing CDRB at Defence Staff Meetings, Chairmanship of the Program

Review Group (see Annex II), coordinating the activities of the two Deputy Chairmen, overseeing the day-to-day operations of the Board and, in general, assisting the Chairman in the discharge of his responsibilities.

7. The Deputy Chairman (Operations) assists the Chairman in carrying out his duties with particular reference to personnel, logistics and finance; public and scientific information; security, and administration of defence industrial and university grant funds.

8. The Deputy Chairman (Scientific) assists the Chairman in carrying out his duties with particular reference to planning, evaluation and reviewing of the scientific program, the provision of scientific support to the Canadian Forces, and international activities.

9. The Research Establishments of the Board are the scientific units which conduct research in various selected fields of Canadian defence interest. The major portion of their program is concerned with applied research and exploratory development addressed to both current and future problems and requirements of the Canadian Forces, the performance of tests and evaluations as well as the modification and fabrication of experimental equipment, components or procedures for the Armed Forces upon request. By these means the Board maintains groups of expert scientists and technologists to provide scientific advice and support to the Minister and the Canadian Forces.

Organizational block diagrams are attached (Appendices A, B and C).

CHANNELS OF COMMUNICATION

10. The composition of the Defence Research Board ensures that formal channels of communication are maintained with the other components of the Department of National Defence, with the National Research Council, with the Department of Defence Production (a senior staff member being, by custom, an appointed member) and with universities, industry and other research agencies.

11. Additional channels of communication between the Board and extramural agencies are provided through an advisory committee structure designed to

advise the Board on research activities in the various fields of pure and applied science where developments of interest to defence may occur. Serving as members of these committees are university professors, representatives of the Canadian Forces, appropriate government departments and agencies, and other scientists expert in the fields under reference.

Appendix D is a block diagram showing the channels of communication.

UNITS RESPONSIBLE FOR SCIENTIFIC ACTIVITIES

12. The research establishments of the Board are the main units responsible for scientific activities. Notes on the individual establishments follow, with organizational charts at Appendices E - L.

The Defence Research Establishment Atlantic, Dartmouth, N.S. (Appendix E)

13. The Defence Research Establishment Atlantic (DREA) is concerned primarily with research related to problems of anti-submarine defence in the North Atlantic including underwater acoustics, signal processing, and transducer research and hydrodynamics. In addition, DREA provides certain dockyard laboratory services for the Canadian Maritime Forces.

The Canadian Armament Research and Development Establishment, Valcartier, P.Q. (Appendix F)

14. The Canadian Armament Research and Development Establishment (CARDE) is concerned with research in the fields of armament, night vision aids and detection devices, propellants and explosives, aerospace research and weapons systems analysis. Its role involves close links with the Canadian Armed Forces, and a substantial number of Service personnel are attached to the Establishment.

The Defence Research Analysis Establishment, Ottawa, Ontario. (Appendix G)

15. The Defence Research Analysis Establishment (DRAE) of the Defence Research Board is also a division of Canadian Forces Headquarters and is staffed by both Defence Research Board scientists and military officers. Operational research scientists, working under the general supervision of DRAE, are also located at the headquarters of some Canadian Forces Commands.

16. The work of DRAE includes the analysis of strategic problems, investigations of maritime, land, and tactical air operations and equipments, analytical studies of North American defence questions, and studies of problems concerning the deployment and utilization of military personnel, programming, and logistics. In addition, DRAE plays an active role in the planning and analysis of various exercises and field trials, and provides certain statistical and mathematical services to the Canadian Forces.

The Defence Chemical, Biological and Radiation Establishment, Shirley Bay, Ontario. (Appendix H)

17. Activities at the Defence Chemical, Biological and Radiation Establishment (DCBRE) consists of research into the defensive aspects of biological, chemical and nuclear warfare, and investigation of electrical power sources (which include batteries, fuel cells, thermionic and thermoelectric devices but not conventional generating systems) and related items.

The Defence Research Telecommunications Establishment, Shirley Bay, Ontario. (Appendix I)

18. The Defence Research Telecommunications Establishment (DRTE) is, as its name implies, concerned with telecommunications. For this purpose it must be highly expert in electronics and the behaviour of radio waves in various media. In the field of electronics, applied research and instrumentation are combined with fundamental investigations into solid-state physics, and with studies of electronic circuits and circuit elements. The communications program is concerned primarily with applied research in radio wave propagation, communications and radar systems, and signal detection. Radio physics studies deal mainly with the physical processes in the upper atmosphere that affect radio propagation.

19. The Defence Research Board's satellite program has been a special feature of DRTE's activities in recent years.

The Defence Research Establishment Toronto, Downsview, Ontario. (Appendix J)

20. The research program of the Defence Research Establishment Toronto (DRET) is concerned with the factors involved in the efficient performance of healthy

servicemen in various adverse operational military environments. Broadly, the role of DRET is to measure and understand the particular capabilities and limitations of human beings which are of special significance in military environments, and to promote recognition of these variables in the design of military equipment and the formulation of training and operational procedures. Its applied research work is supported by a program of closely related fundamental research.

The Defence Research Establishment Suffield, Ralston, Alberta. (Appendix K)

21. Defence Research Establishment Suffield (DRES) consists of a central laboratory and associated facilities, together with a secure test area of 1,000 square miles with access roads, communications systems, and power supplies. The Establishment conducts basic and applied research on problems concerned with defence against biological, chemical, and nuclear warfare. The programs of DCBRE and DRES are complementary and closely coordinated.

The Defence Research Establishment Pacific, Esquimalt, B.C. (Appendix L)

22. The Defence Research Establishment Pacific (DREP) is primarily engaged in research leading to improved methods for the detection of submerged submarines with special reference to Pacific Ocean conditions. The effort is mainly distributed among three fields of physical research — underwater acoustics, low-frequency electromagnetics, and fluid dynamics. It also provides scientific and engineering consultative services and assistance to Maritime Forces on the Pacific coast.

Formal Agreements with Foreign Agencies

23. The Defence Research Board is formally involved with foreign countries and foreign defence science agencies as the designated representatives of the DND in some cases and as a signatory in others. A brief description of the various agreements follows.

(a) *North Atlantic Treaty Organization (NATO).* The Department's scientific activities under the NATO agreement are primarily carried out by scientists of the Defence Research Board (DRB) who participate on behalf of the Department in defence science meetings, studies and seminars in collaboration with the defence scientists of other NATO

nations. In particular, DRB supports the NATO Defence Research Group and its panels, the SHAPE Technical Centre, the SACLANT Anti-Submarine Warfare Research Centre and the Advisory Group for Aerospace Research and Development (AGARD).

(b) *Bipartite Agreements with NATO Nations.* DRB has bipartite agreements for the exchange of defence science information with Norway, the Netherlands, West Germany, Greece, France and Denmark. These agreements are almost identical in wording and are primarily aimed at facilitating the exchange of information and simplifying the procedure for defence liaison visits by scientists.

(c) *The Technical Cooperation Program (TTCP).* This program is based upon an agreement between Canada, the United States, Britain and Australia to collaborate in defence science with the aim of improving their combined efficiency and minimizing duplication of effort. DRB has the primary responsibility on behalf of the Department for operating the program. The activities are divided into specialist groups covering the various fields of common defence interest.

(d) *The Defence Research Board/Royal Canadian Air Force/United States Air Force (DRB/RCAF/USAF) Agreement.* This agreement, signed December 1958, facilitates the exchange of defence science information between the Department and the USAF.

(e) *The Commonwealth Defence Science Organization (CDSO).* This organization, which was established shortly after World War II, is the basis for exchange of defence science information between the countries of the Commonwealth. Its activities include exchange of documents, seminars and collaborative projects. DRB represents the Department and provides a member to the central committee in London, England.

(f) *The Defence Research Board/National Aeronautics Space Administration (DRB/NASA) Agreement.* This agreement covers the collaboration between the Defence Research Telecommunications Establishment (DRTE) of DRB

and NASA for launching and subsequent operation of the Alouette and International Satellite for Ionospheric Studies (ISIS) satellites.

(g) *The Canadian Armament Research and Development Establishment/Advanced Research Projects Agency (CARDE/ARPA) Agreement.* This agreement covers the collaboration between CARDE of DRB and ARPA on that part of CARDE's program which is related to defence against ballistic missile attack of North America.

(h) *Initial Defense Communications Satellite Project (IDCSP).* This agreement covers collaboration between DRTE and the US Army under which DRTE is permitted to make use of US military communications research satellites in conjunction with Canadian developed ground equipment for research purposes.

Offices in Other Countries

24. Since its inception, the Defence Research Board has maintained liaison offices in the United Kingdom (London) and U.S.A. (Washington, D.C.). Originally integral parts of the Canadian Joint Staffs, they were separated in late 1965 and redesignated "Canadian Defence Research Staff" with the Chief in each case having the following duties:

(i) to act generally as the agent of the Chairman of the Defence Research Board in conducting liaison with the appropriate authorities on defence research and development in his country of assignment;

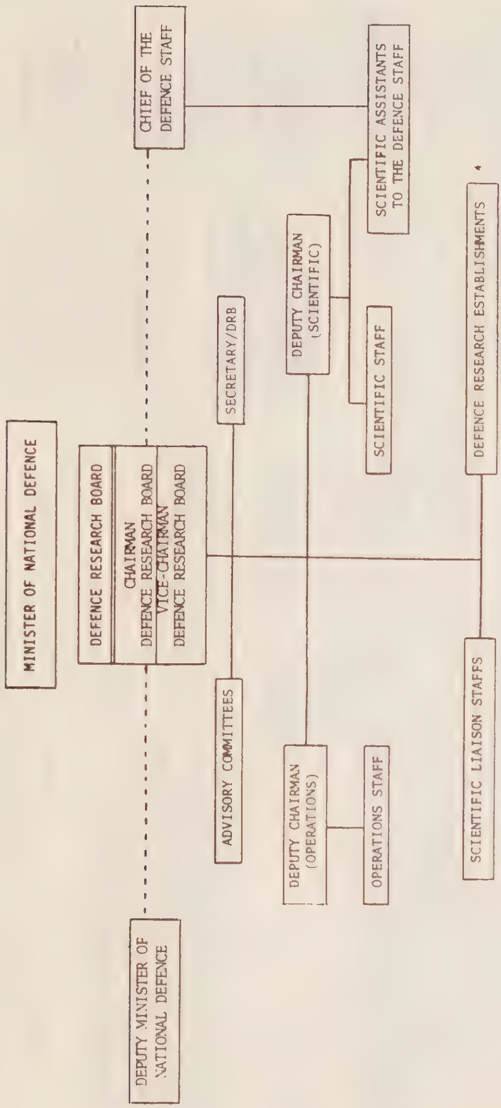
(ii) to act as defence research adviser to the Canadian High Commissioner in the United Kingdom and to the Canadian Ambassador in the United States;

(iii) to obtain documentary information of a scientific and technical nature required by the Defence Scientific Information Service on behalf of the Chief of the Defence Staff as well as the Defence Research Board;

(iv) to assist as required in any other local negotiations in the interest of the Defence Research Board.

25. In mid-1965, in order to develop and systematize contacts and relationships with a number of laboratories in France concerned with defence research matters, the post of "Defence Research Attaché" was created on the staff of the Canadian Ambassador of France. It is the duty of the Defence Research Attaché to further the objectives of the Defence Research Board through personal contact with French defence research laboratories, to keep Defence Research Board headquarters and establishments informed of programs and projects in which there appears to be a mutual interest, and to foster exchange of information through visits, correspondence and scientific reports.

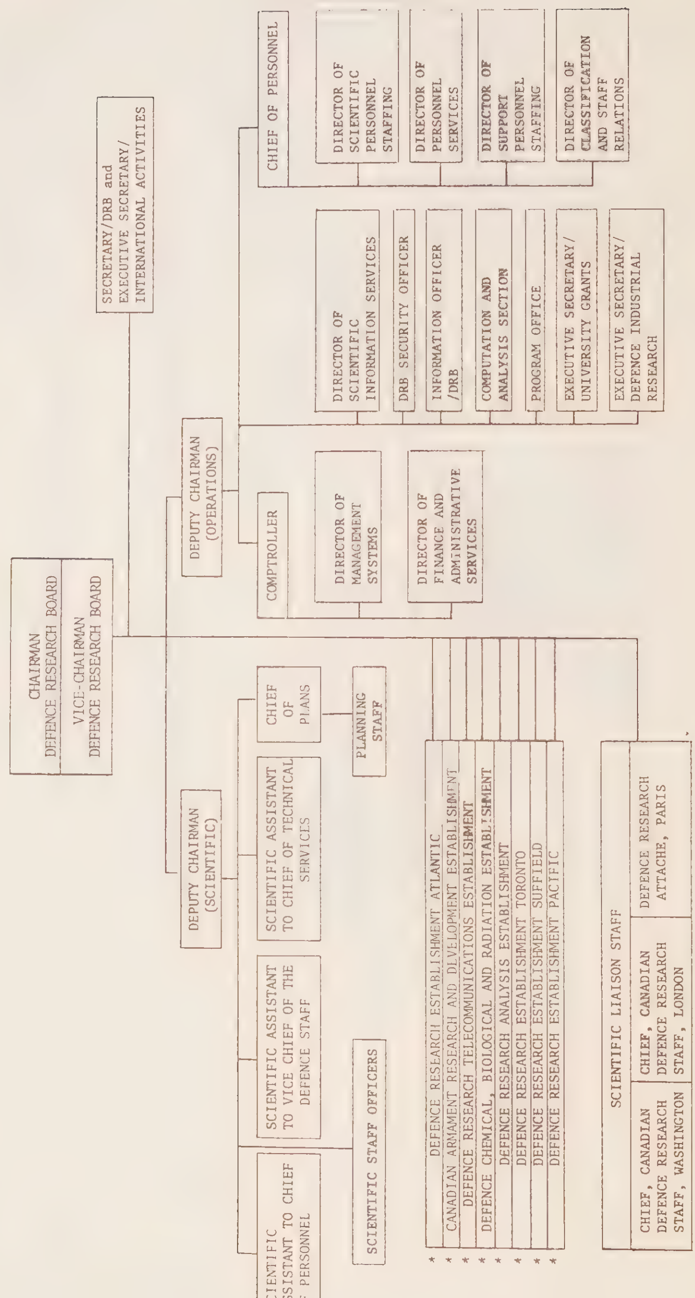
APPENDIX A - ANNEX I



* *Units conducting or funding scientific activities*

APPENDIX B - ANNEX I

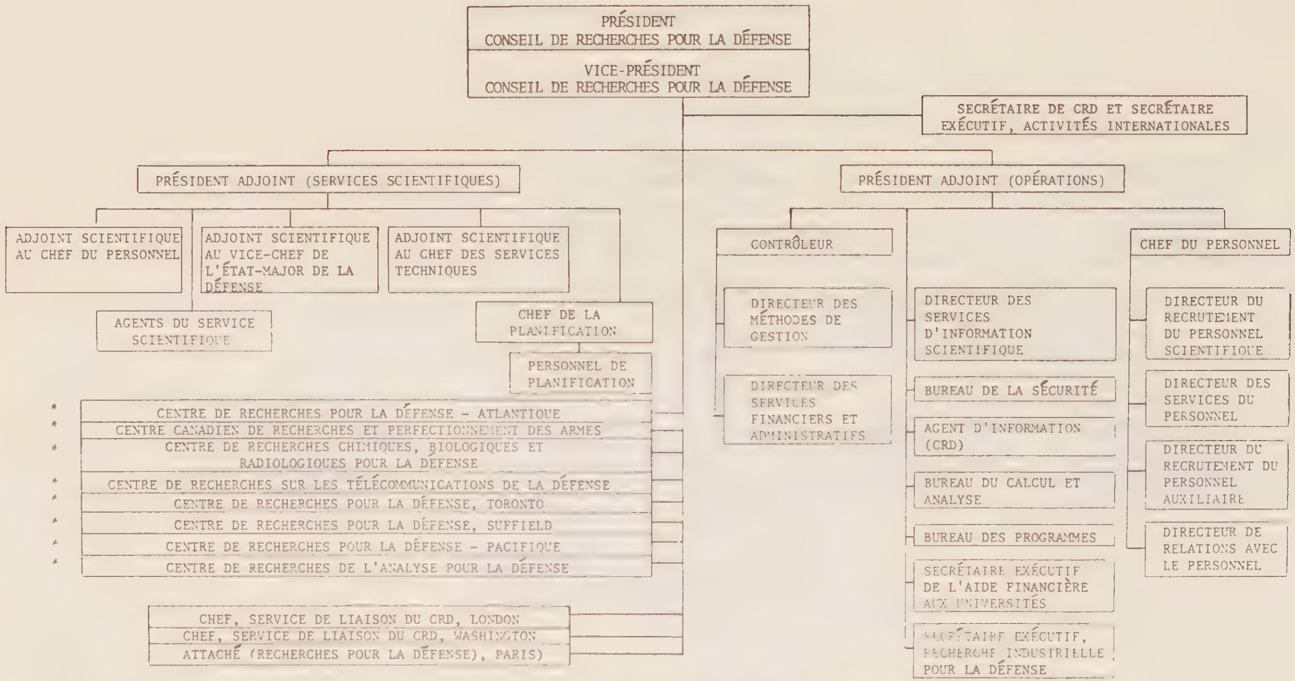
DEFENCE RESEARCH BOARD ORGANIZATION



* *Units conducting or funding scientific activities*

APPENDIX C - ANNEX I

ORGANISATION DU CONSEIL DE RECHERCHES POUR LA DÉFENSE



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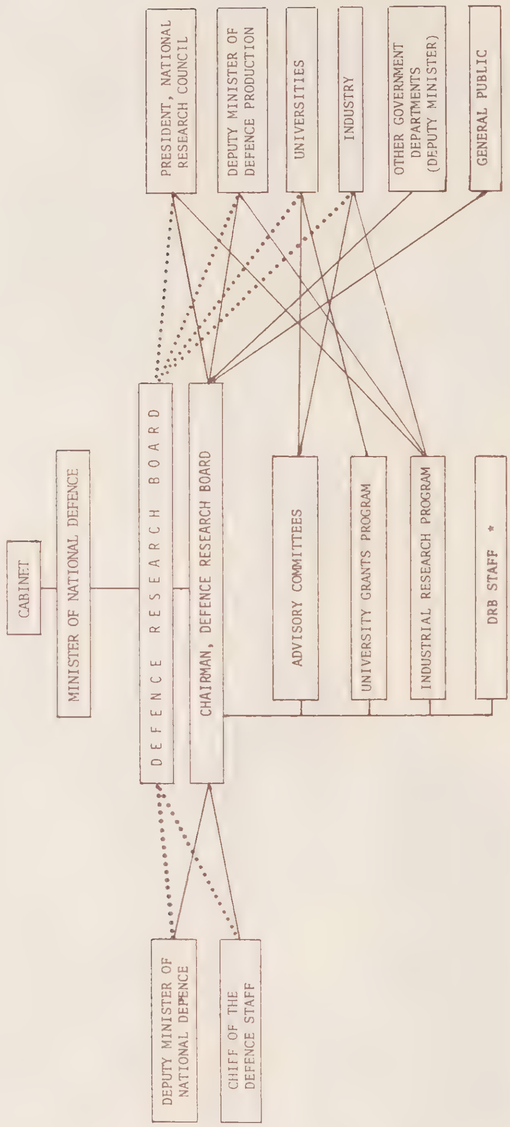
APPENDIX D - ANNEX I

CHANNELS OF COMMUNICATION



Legend: ·········· = *Channel from* Defence Research Board

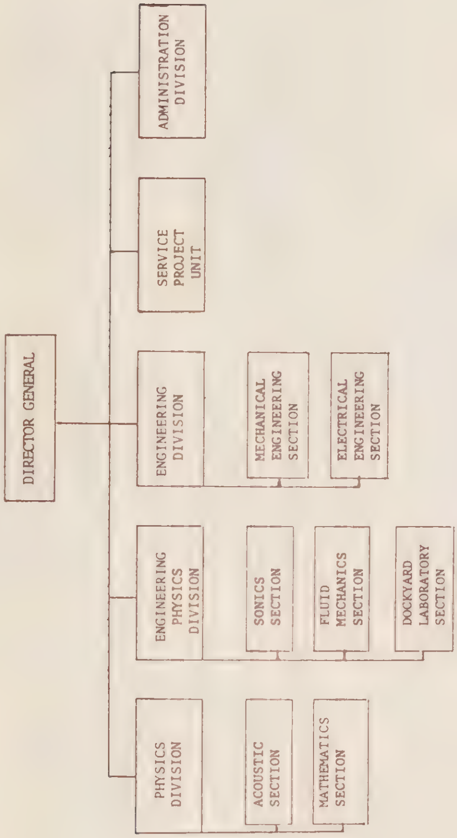
——— = *Channel from or through* Chairman, Defence Research Board

* = *Unofficial or specifically approved official "working level" channels only*

APPENDIX E - ANNEX I

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

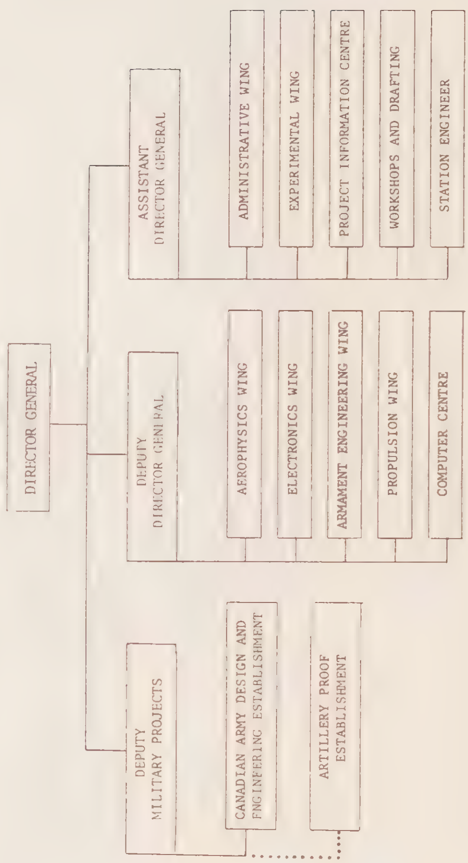
CENTRE DE RECHERCHES POUR LA DÉFENSE - ATLANTIQUE



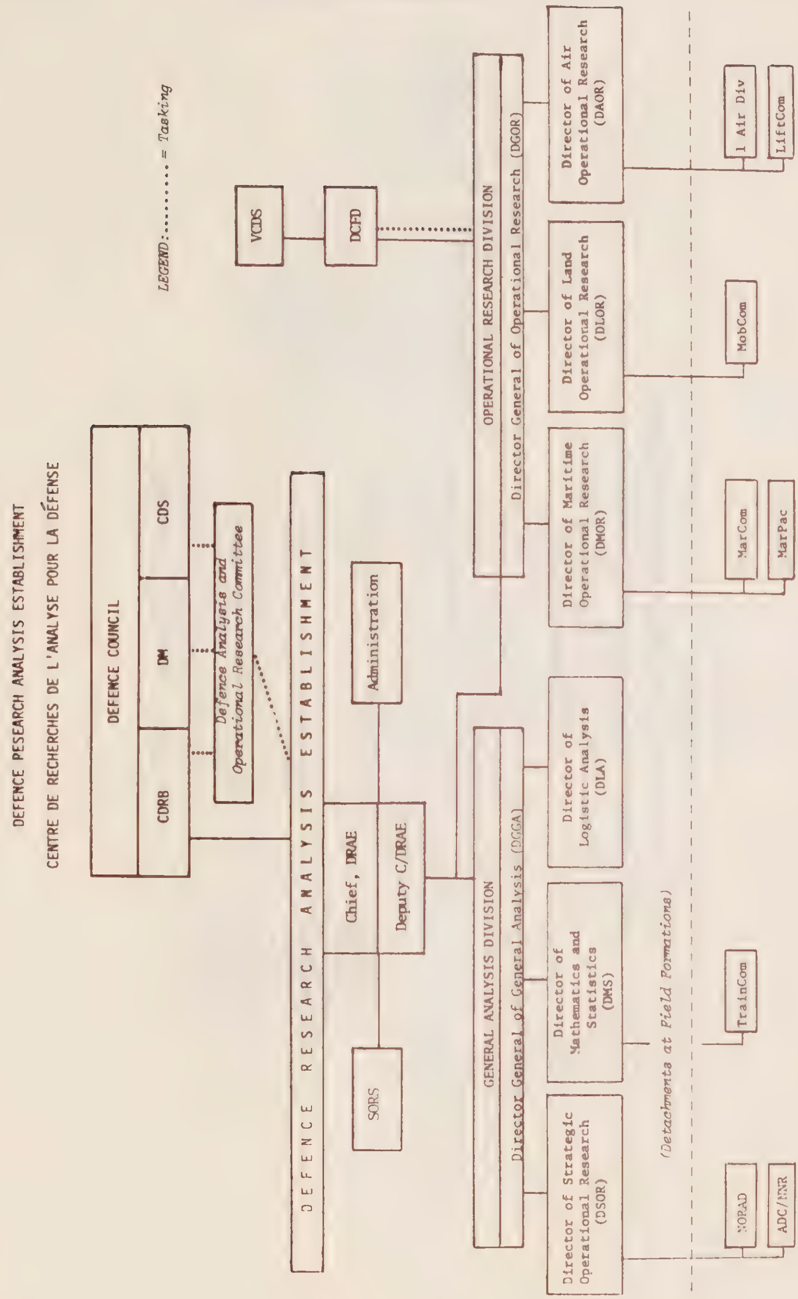
APPENDIX F - ANNEX I

CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

CENTRE CANADIEN DE RECHERCHES ET PERFECTIONNEMENT DES ARMES



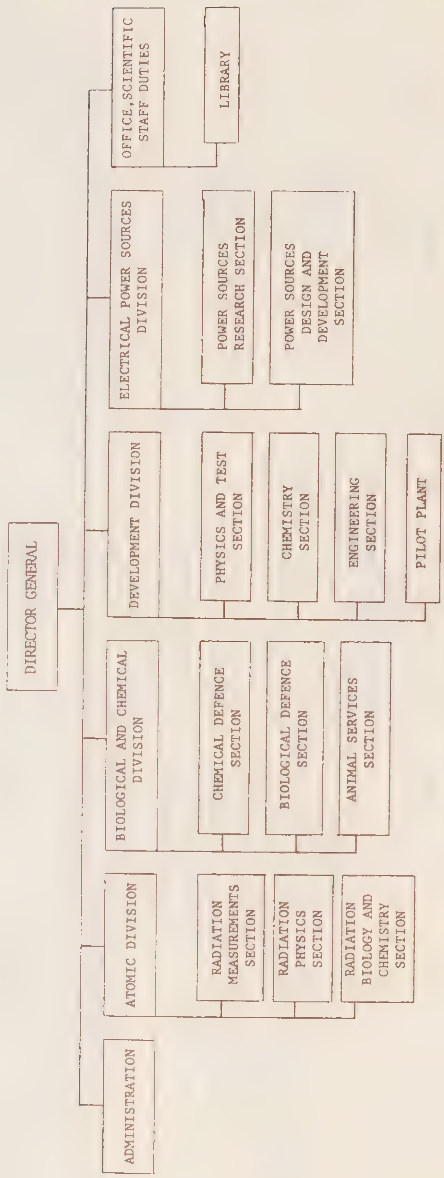
APPENDIX G - ANNEX I



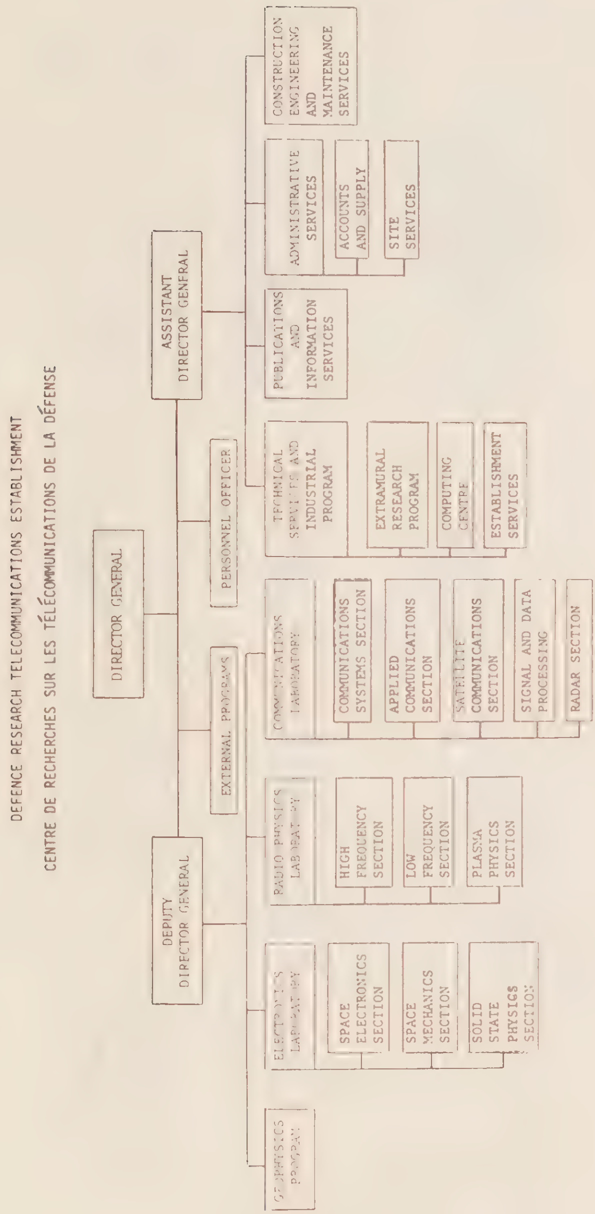
APPENDIX H - ANNEX I

DEFENCE CHEMICAL, BIOLOGICAL AND RADIATION ESTABLISHMENT

CENTRE DE RECHERCHES CHIMIQUES, BIOLOGIQUES ET RADIOLOGIQUES POUR LA DÉFENSE



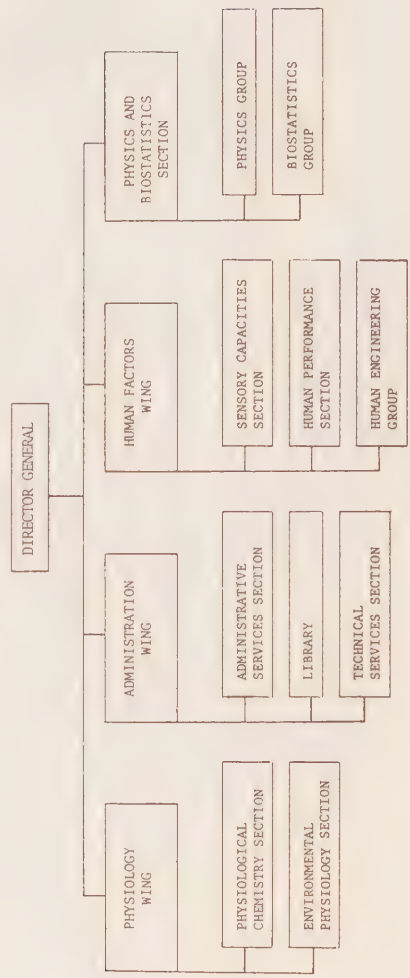
APPENDIX I - ANNEX I



APPENDIX J - ANNEX I

DEFENCE RESEARCH ESTABLISHMENT TORONTO

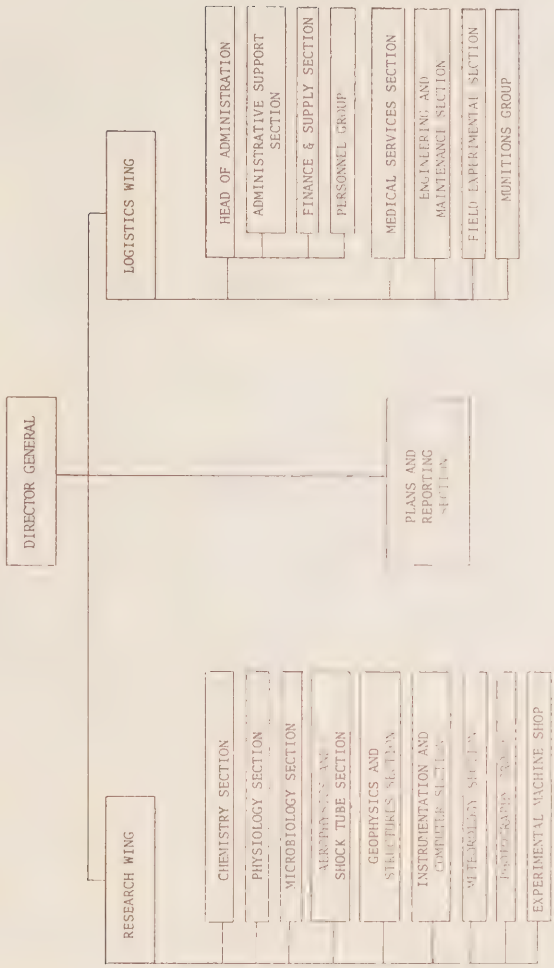
CENTRE DE RECHERCHES POUR LA DÉFENSE, TORONTO



APPENDIX K - ANNEX I

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

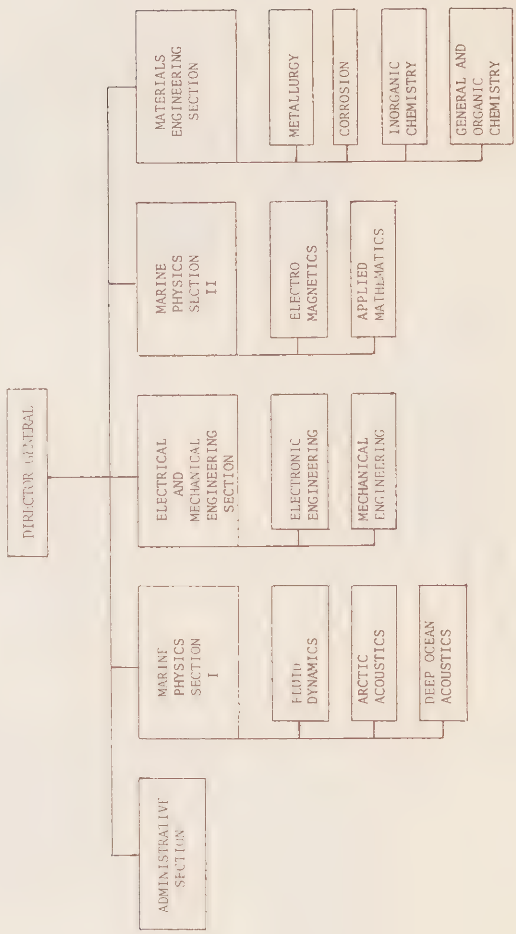
CENTRE DE RECHERCHES POUR LA DÉFENSE, SUFFIELD



APPENDIX L - ANNEX I

DEFENCE RESEARCH ESTABLISHMENT PACIFIC

CENTRE DE RECHERCHES POUR LA DÉFENSE - PACIFIQUE



APPENDIX M - ANNEX I

ABBREVIATIONS

DEFENCE RESEARCH BOARD	DRB
CHAIRMAN, DEFENCE RESEARCH BOARD	CDRB
VICE-CHAIRMAN, DEFENCE RESEARCH BOARD	VC/DRB
DEPUTY CHAIRMAN (SCIENTIFIC)	DC(Sc)
DEPUTY CHAIRMAN (OPERATIONS)	DC(O)
COMPTROLLER	Compt/DRB
CHIEF OF PERSONNEL	C of P
SCIENTIFIC ASSISTANT TO VICE CHIEF OF THE DEFENCE STAFF	SA/VCDS
SCIENTIFIC ASSISTANT TO CHIEF OF TECHNICAL SERVICES	SA/CTS
CHIEF OF PLANS	CPLANS
DEFENCE RESEARCH ESTABLISHMENT ATLANTIC	DREA
CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT	CARDE
DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT	DRTE
DEFENCE CHEMICAL, BIOLOGICAL AND RADIATION ESTABLISHMENT	DCBRE
DEFENCE RESEARCH ANALYSIS ESTABLISHMENT	DRAE
DEFENCE RESEARCH ESTABLISHMENT TORONTO	DRET
DEFENCE RESEARCH ESTABLISHMENT SUFFIELD	DRES
DEFENCE RESEARCH ESTABLISHMENT PACIFIC	DREP
CANADIAN DEFENCE RESEARCH STAFF, LONDON	CDRS(L)
CANADIAN DEFENCE RESEARCH STAFF, WASHINGTON	CDRS(W)
DEFENCE INDUSTRIAL RESEARCH PROGRAM	DIR

ANNEX II — ORGANIZATIONAL FUNCTIONS

STATUTORY FUNCTIONS

1. The statutory functions and powers of the Defence Research Board are contained in Part III (Section 53, 54 and 55) of the National Defence Act which is reproduced as Appendix A.

2. Briefly, the functions of the Board are "to carry out such duties in connection with research relating to the defence of Canada and development of or improvements in materiel as the Minister of National Defence may assign to it, and to advise him on all matters relating to scientific, technical and other research and development that in its opinion may affect national defence".

EVOLUTION OF ORGANIZATIONAL POLICIES AND PRINCIPLES

3. Immediately following the cessation of hostilities in 1945 consideration was given to the problems of organizing government scientific research in peacetime. In 1939 the National Research Council had one laboratory and a staff of 300; by the end of the war it had nearly 2,000 employees working in 21 laboratories, engaged almost entirely in military research at the expense of fundamental research and problems important to the civilian economy.

4. The then President of the National Research Council, Dr. C.J. Mackenzie, stated that in his view both civilian and military research were major fields in themselves and that each required the full attention of a top directing staff. He felt that if NRC took on the additional responsibility for military research either the civilian or military aspect of its work would be neglected. He also pointed out that in matters of military research user knowledge was important and could only come from the Forces themselves. He urged that the Council should not be asked to continue to carry out military research.

5. Agreement was reached in 1946 that defence research should be the function of an agency within the Department of National Defence and that the effort should be closely related to the scientific work of a similar nature being done in Britain and the United States. The Defence Research Board came

into being and took over direction of the majority of military research establishments being operated by the Navy, Army and Air Force. In relation to Britain and the United States it was understood that Canadian research should be concentrated in certain special fields where Canada, by virtue of her climate, geography, industrial capacity or unique experience and facilities would be able to make the most effective contribution to the common scientific effort.

6. In the period since 1946 the Board's organizational policies have been the subject of frequent review, revision and restatement. However, certain basic principles have stood the tests of time and experience and have remained unchanged.

7. One of the most important principles is that the scientific quality of its work and its staff must not be compromised. Every effort is made to employ only first class scientists of proven ability and to give them first class equipment and facilities with which to work. In the face of severe competition in recruiting DRB must ensure good working conditions with competitive salaries and be able to offer attractive careers in both research and administration.

8. These principles were recognized during its creation and the Board was given freedom, flexibility and independence in the selection and personnel management of its staff within the limits of a personnel establishment approved by Treasury Board.

9. The Board also recognizes a number of principles which are applicable whenever decisions are made on the nature, scope and magnitude of its research programs whether carried out within the Board's establishments or extramurally in universities and industry. The first of these is that its advisory and supporting role to the Minister and the Forces is its primary and major responsibility, contributing to the collective efforts of our allies in defence research comes second, and the support of university and industrial research related to defence comes third. However, another important principle is that the proper balance between long-term and short-term programs must be

maintained. It is important that the Board foresee future scientific and technological development by keeping Canadian defence science in the forefront of advances to new knowledge. Its attention must therefore not be concentrated entirely on current problems, or even on the clearly apparent problems of the immediate future. Short-term requirements of obvious defence interest must be weighed against longer-term — or perhaps more basic — research, and both must be matched against available resources.

10. In 1967 policy concerning the operations of the Board was critically and thoroughly reviewed. The outcome was the adoption of a policy of decentralization by which the responsibilities for program implementation and associated staff duties were transferred from headquarters to the establishments while retaining the responsibilities for program planning and review, military support planning, and personnel and financial management in headquarters.

11. These changes were made to accomplish several purposes. One purpose was to develop closer links between DRB and the Services at both the higher "management" levels and the working scientist level. Two benefits are expected — our scientific support to the Services will be strengthened and conversely the needs of the Services will become better known at all levels within DRB — but particularly in the laboratories where ideas and work will be influenced. In other words we want our scientists to be familiar with military problems, attitudes and thinking so that they will be defence scientists, rather than just scientists in a defence establishment. A second purpose was to free headquarters management and its staff from the concerns of daily operations to concentrate on the policy and planning aspects of DRB's scientific program and its support to the Services. A third purpose was to ensure strong scientific and technological links from establishments to universities and to industry. Finally, it would provide better career opportunities for scientists and make more effective use of available resources to meet DRB obligations.

DRB FUNCTIONS AND RESPONSIBILITIES VIS-A-VIS OTHER ORGANIZATIONS

12. In Relation to Other Federal Agencies. While the Board has no statutory functions or responsibilities in relation to other Federal departments and agencies its policy is to provide reciprocal assistance by making available to such agencies both its particular scientific and technological expertise and the services of its research facilities.

13. In the matter of facilities the laboratories of the Board are extremely well equipped and some are fortunate enough to possess facilities which are unique in Canada. Examples of such include the CARDE Hypersonic Ranges, the DREA Acoustic Calibration Facility, the DRET Diving Unit, and the DRES Shock and Blast Laboratory. Added to this is the fact that in some instances the geographic location of the laboratories make them particularly well suited to certain types of investigation — as in the case of the Defence Research Establishment Suffield with its 1,000 square miles of test area.

14. With the facilities at its disposal and its acknowledged expertise in certain fields the Board is well equipped to provide assistance, and over the years requests for assistance have been many and varied. A few examples follow which illustrate the kinds of assistance provided in the past.

(a) *Department of Industry and former Department of Defence Production.* During the past two years an increasing number of instances have occurred when the Canadian Armament Research and Development Establishment (CARDE) assistance has been sought by the Department of Defence Production (DDP) in connection with problems associated with the industrial production of various types of ammunition. This investigative work has on occasion involved production orders in excess of a million dollars. Approximately two professional man years for each of the past two years has been involved in this work — an effort extremely small in relation to the resultant production savings.

(b) *Department of Transport.* A continuing requirement exists to increase wherever possible the efficiency of the operation of ships in both Canadian defence and in general government service. As the solution

to many such problems is frequently provided by the application of human engineering principles, the assistance of the human engineering group at the Defence Research Establishment Toronto (DRET) is frequently sought, particularly by the Department of Transport.

For example, during the past six years a machinery and control room and two major bridge mockups have been produced by DRET to demonstrate the incorporation of such principles in facilities for ship operation and control. As a result of this work a bridge layout for all equipment for a GP frigate was accepted by the RCN and led to similar work and acceptance of design for Coast Guard icebreakers. The designs have also been used in over a hundred US ships.

(c) *Department of Energy Mines and Resources.* For many years the Defence Research Establishment Atlantic (DREA) has been concerned with the calibration and repair of bathythermographs for various government agencies and universities. In 1967, agencies included the Great Lakes Institute, Province of Quebec and the Atlantic Oceanography Laboratory of the Bedford Institute of the Department of Energy Mines and Resources.

Another DREA facility of which extensive use is made by other agencies is the FP-6000 computer system. During 1965 approximately 18% of the available DREA computer time was devoted to the Bedford Institute's computations.

15. Just as it is the policy of the Board to provide assistance to other departments so it is also the policy to obtain assistance from them. For although DRB has built up a significant scientific and technological capability it has not itself attempted, nor is it desirable that it should attempt, to undertake all research aspects of every project for which military requirements call. Instead it has endeavoured to utilize such expertise and facilities as already exist in other federal departments, agencies and the universities. In such cases where arrangements are made to utilize a facility outside DRB, the Board retains responsibility for arranging and coordinating such support, and for the overall direction of the project.

16. The agency with which DRB has been in close association over the longest period has undoubtedly been the National Research Council, which prior to the establishment of DRB played the major part in Canadian defence science. Although the Council's responsibilities in the area ceased with the creation of DRB there are still a few areas such as aeronautics, hydrodynamics and magnetics in which it provides the Board with advice and assistance in respect both of direct support of military requirements, and of certain aspects of the Board's long-term intramural basic research programs. Frequent use is also made of the Department of Energy, Mines and Resources in a number of fields such as materials, in which that organization has the primary competence, and in such areas as geophysics, oceanography, and nuclear science where the advice and assistance of this Department is also of great value to us. Other government departments and agencies which provide assistance in support of military requirements, include the Department of Transport, the Department of Agriculture, the Department of National Health and Welfare, the National Aeronautical Establishment, the Fisheries Research Board, and Atomic Energy of Canada Limited.

17. In Relation to Industry. The Board's policy with respect to industry is one of collaboration and assistance wherever possible. Liaison with industry is maintained at all levels from the Board itself down to the scientists at the laboratory bench. The Board's establishments augment their intramural research projects by means of research contracts* with industrial research laboratories. In the period 1962/63 to 1967/68 DRB has spent $20.4 million on research contracts with industrial firms. This does not include the Electronic Components Research and Development program administered by DRB and funded jointly by DRB and the Canadian Forces which has involved the spending of $11.5 million on research and development contracts in the same

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* There is a distinction to be noted between industrial research contracts and grants for industrial research. The research being done under contract is formulated, directed and controlled by DRB and is needed to augment its intramural program. Grant research projects are formulated, directed and controlled by industrial scientists and are not necessarily related to intramural programs. DRB's role is confined to technical advice and financial support.

period. The Defence Industrial Research grants program and the Research Satellite Program expenditures are excluded also (See Annex VI).

18. While it is not a statutory function of the Board to provide scientific and technical advice to industry, nevertheless the Board does so whenever there are significant defence implications and the priorities of the research program permit. An example is the support provided industry in the manufacture of Black Brant Rockets which were originally designed and produced at CARDE. Another example is the production of the ISIS-A satellite by RCA Victor under contract with the objective of transferring know-how in satellite design and fabrication to industry. A brief description of the Research Satellite Program showing DRB's role is attached as Appendix B. A third example is the close collaboration of the Power Sources Section of DCBRE with the battery industry with the objective of enabling Canadian industry to produce the more efficient and longer-lived batteries so essential to defence equipment of all types.

19. In Relation to Educational Institutions. The Board has, of course, no statutory responsibility or function relating to the support of educational institutions. It does, however, have a direct interest in obtaining the good will and assistance of scientists who are members of university staffs and is authorized under the National Defence Act to make grants in aid of research to university staff members to undertake research projects of defence interest. Many of the university staff serve the Board gratuitously as members of its advisory committees and panels. Approximately $30 million were spent on the university grants program between 1947 and 1968; the funding level rose from $0.3 million in 1948 to a funding level of approximately $1.6 million in 1960/61, was roughly $2 million for 1962-66 and has been about $3 million since then.

20. The Board is also interested in employing scientists of the highest calibre. To foster an interest in accepting employment with the Board, upwards of one hundred selected undergraduate and graduate students work in the Board's establishments each year during the academic summer vacation. This program has been successful as many have joined the Board after graduation

or postgraduate training. The National Defence Act authorizes DRB to establish scholarships for the education and training of persons to qualify them to engage in such research.

21. •As is the case with industry, the Board's establishments augment their intramural research projects by entering into research contracts with scientists working in their own university laboratories. In the years 1962/63 to 1967/68 approximately $9.6 million has been spent for university research contracts, in addition to approximately $960,000 for university research contracts under the Electronic Components Research and Development program.

22. In Relation to Foreign Scientific Activities. The Board's responsibilities regarding international scientific activities were described earlier in Annex I. These are discharged by participation in the work of committees, panels, working groups, etc. The representatives on such bodies are drawn from establishments, except in the case of some senior bodies on which the representatives are senior headquarters officers. The representatives are responsible for monitoring the scientific activities in their fields of interest and for making their knowledge available to all those who have an interest.

INTERNAL REVIEW PROCESSES

23. Broad policies of the Defence Research Board (which relate to science and internal operations) are determined by the Chairman in consultation with the Minister of National Defence, Members of the Defence Research Board, Senior DRB officers (at Headquarters and Establishments), and Senior Officers of the Canadian Armed Forces.

24. Within the established broad policies, a senior staff at Headquarters and five committees advise and/or make recommendations to the Chairman on matters dealing with operational effectiveness, duties, and goals.

25. More specifically, the Headquarters staff is divided into two main groups. The first group being under a Deputy Chairman (Scientific) and responsible for development of defence science policy, program planning and

review, and military liaison. Essentially, this group reviews the goals and effectiveness of the scientific program and makes recommendations on revisions either directly to the Chairman or through the Program Review Group (see para. 27).

26. The second group is under a Deputy Chairman (Operations) and is responsible for ensuring that the finances, personnel, and other resources are available and employed to their maximum effectiveness in accordance with agreed program priorities. The availability and disposition of all the Board's resources are accounted for and displayed; hence if changes have to be made in the program, the feasibility and implications of these changes in resource allocation are clear and self-evident. Internal operating procedures of the research establishments are the responsibility of each establishment Director-General (which is in keeping with DRB's decentralization concept); however, these procedures are monitored by this second group to ensure that they are effective, and within the general concepts and policies of accounting and control established (and updated) by headquarters.

27. The five committees which advise the Chairman on operational effectiveness, duties, and goals are:

(a) Defence Research Council — considers general matters regarding policy, plans, and programs. It consists of the Chairman, Vice-Chairman, Directors-General of the establishments, and senior officers at headquarters.

(b) Program Review Group — in order to advise and make recommendations to the Chairman, the Group keeps the scientific program, organization, and operations under continual review with the object of maintaining a balanced and relevant program; ensures the resources of manpower and money are allocated in accordance with approved policy, plans, priorities, and budgetary limits; conducts periodic examinations of resources required for future years in accordance with the long range defence science policy. The Program Review Group is composed of the VC/DRB (Chairman), the two Deputy Chairmen, CPlans, Comptroller, SA/√CDS, SA/CTS and SA/CP.

(c) Personnel Committee — considers all aspects and factors affecting the whole sphere of personnel management; advises on promotions, postings, and careers of scientific officers. The members of the Personnel Committee are DC(O) (Chairman), DC(Sc), Compt, CofP and CPlans.

(d) University Grants Review Committee — considers all matters affecting the University Grants Program; reviews and recommends on allocation of funds. (See Annex VII for Membership).

(e) Advisory Committee on Defence Industrial Research — considers all aspects of the defence industrial research grants program and recommends the awarding of grants. (See Annex VII for Membership).

COMMISSIONED OUTSIDE STUDIES OF OPERATING PROCEDURES

28. Two studies were commissioned outside DRB as follows:

(a) September 1963. Management Analysis Division, Civil Service Commission. Survey of Personnel Records of the Defence Research Board.

(b) March 1968. Stevenson and Kellogg Ltd., Montreal. Job Evaluation and Wage Study for the CARDE Workshops.

RELATIONSHIP BETWEEN THE BOARD'S RESPONSIBILITIES AND ITS ACTIVITIES

29. Stated simply and concisely DRB's primary objective is to provide scientific advice and support to the Minister and the Armed Forces. The following derived and secondary objectives are currently recognized:

— to carry out research in scientific fields relevant to defence,

— to carry out applied research and exploratory development to meet the needs of the Armed Forces,

— to perform tests and evaluations and to modify or fabricate equipment, components and procedures of the Armed Forces upon request,

— to maintain an awareness in Universities of defence interests and requirements,

— to support applied defence research in Canadian industry,

— to provide a central and national defence scientific information service,

— to maximise the exchange of defence scientific information between Canada and its Allies.

— to assist other Federal Departments on request.

30. The work DRB does to meet all these objectives can be displayed under five activities as follows:

(i) Defence Research and Preliminary Development

This activity embraces all critical and exhaustive scientific studies, enquiries and investigations primarily necessary for the discovery and interpretation of new facts and the application of these to the design of improved materials, equipment or processes and to the solution of other practical problems.

(ii) Direct Technological and Analytical Support to Canadian Armed Forces

This activity consists of all scientific and technological activities exclusive of research and information services, which are performed primarily in support of operational commands and units and technical branches of the Canadian Forces and other Federal Departments. It also includes the support given to the Armed Forces by the Defence Research Analysis Establishment.

(iii) Defence Scientific Liaison and Information Services

This activity consists of all work carried out to exchange scientific and technical information by means other than scientific studies, enquiries, and investigations. e.g. DSIS, the London and Washington Offices of DRB. (Appendix C describes briefly the functions of DSIS).

(iv) Stimulation and Support of Defence Oriented Research

This covers all the resources allocated to the creation and maintenance of defence research interests and capabilities in universities and industry.

(v) *Central Administration*

This activity embraces central management and its branches, including personnel services and administration.

31. The intramural scientific programs and projects are represented by the first two activities except for DRB's special assignment to assist in the development and construction of ionospheric satellites by industry. The five activities form the basis of an analytical and planning method being developed by DRB in the application of the Planning-Programming-Budgeting approach to the allocation of its resources. Appendix D is an elaboration of Activity 1 which may be of interest.

HINDRANCES TO THE EFFECTIVE DISCHARGE OF DRB RESPONSIBILITIES

32. There are many intrinsic difficulties associated with research, such as the uncertainty of the nature and significance of future progress in science and technology, the impacts of technological and economic changes, etc. These will always be with us and will not be dealt with in this section. Hindrances, on the other hand, may be considered as obstacles imposed by circumstances or external factors which are beyond the Board's control. This is the sense in which the term hindrance is used in this section.

33. DRB's responsibility is to provide effective advice and support to the Minister and the Canadian Forces. To be effective its advice and support must be relevant to their needs *and* available when needed i.e. timely.

34. The time between the initiation of research and the realization of its benefits is measured in years. Hence the ability to anticipate defence needs some years from now is a critical factor in the selection of research programs and projects. Having selected the programs and projects it is essential that adequate resources be available if the results are to be timely.

35. In order to select the research areas of greatest relevance and importance 5-10 years from now, one must assume, with some reasonable degree of confidence, what the roles and missions of the Canadian Forces will be at that time. These are, of course, critically dependent on Canada's foreign

policies and defence commitments (e.g. its future roles in NATO, UN peacekeeping, etc.) for these will determine to a large extent both the equipment the Forces will require and the natural, sociological and political environments in which they may be required to operate. Furthermore, these will determine which nations will be our future allies and also our present allies' attitudes towards sharing their defence research information with us. This latter point is an important factor in selecting research areas in which *Canada* should be active. The reason is that, having limited resources in comparison with those of our major allies, we have to concentrate our efforts in those areas which are of greatest importance to Canadian defence *and* of major importance to our allies so that we may obtain information in return for ours.

36. Although official statements of government policy concerning external affairs and defence have existed during the period under review, it is well known that these have been subject to repetitive questioning and review both within the government and outside it. This has created considerable uncertainty for those whose work must be planned and conducted so as to come to fruition in 10-15 years' time. It should not be surprising therefore that the air of uncertainty regarding future governmental defence policies and the future roles and missions of the Canadian Forces, and the relative priorities of such roles, has made program planning and project selection in DRB quite difficult.

37. The problems created by the uncertain future Canadian defence posture have been compounded by the stringent budgetary restraints placed on the Department as a whole. The escalation of costs has had two effects relevant to DRB. It has resulted in a continuing decline in the funds available to the Forces for development and the effect of this is that DRB cannot be sure that, even if its applied research is successful, the Forces will be able to exploit it. This is a serious hindrance in project selection. The restraints and cost escalations have also applied to DRB's own operations. Increased salaries and high equipment costs are reducing the number and extent of projects. In fact DRB's financial ceiling has prevented it from recruiting to its manpower ceiling. Sudden major changes in Government policy and

restrictions and cut-backs in available funds have not taken into account the lead time required to make corresponding changes in the research program.

38. A circumstantial hindrance to our effectiveness is the shortage of suitable professional recruits. Such shortages tend to show up more acutely in certain fields. At several establishments a lack of applied mathematicians and senior computer programmers in Canada has impeded work for as long as a year or two. In the past year five experimental psychologists and sociologists have been sought for one establishment and not one suitable person has been recruited. Several years ago the progress of a research program was threatened by the inability to hire sufficient experienced hydrodynamicists.

39. The qualifications of professional staff are a hindrance when it comes to changing research programs. One cannot switch professionals qualified in one field to an unrelated field (e.g. chemists to electronics) and this is a severe restraint on the extent and rapidity of execution of internal program changes.

40. The responsibility for the timely prosecution of research projects should carry with it the freedom to adjust the allocation and expenditure of resources to make optimum use of them as circumstances change. DRB's operational flexibility has been hindered by rules imposed by other agencies such as Treasury Board. For example funds cannot be transferred from one research establishment to another without TB approval, or again funds allocated for salary purposes cannot be used for other purposes. However with the advent of the Planning-Programming-Budgeting System there are signs that the situation will improve.

41. Another hindrance is a result of the government designation of a separate department as the purchasing agent for the Department of National Defence. This imposes a middleman between DRB and the seller and often creates serious delays in purchasing of urgently-needed equipment and beginning contract research in industry and universities. Rules and procedures that are suitable for purchase of market-place commodities are not suited for the purchase of sophisticated scientific equipment or contracting to have research done by other agencies.

MAJOR CHANGES IN DRB ROLES AND OBJECTIVES 1969-1974

42. No major changes in DRB's roles and objectives are being planned but may arise, nevertheless, as a result of major changes in Government policies regarding science or defence. Major shifts in emphasis and resource allocations among programs and projects are, of course, different matters and are a natural outcome of the internal review processes described in paragraph 20.

APPENDIX A — ANNEX II

OFFICE CONSOLIDATION OF PART III, NATIONAL DEFENCE ACT (AS AMENDED TO 1967)

Authorities: Revised Statutes of Canada, 1952, Chapter 184
Statutes of Canada 1950, c. 43; 1964-65, c. 21; 1966-67, c. 26, s. 13

THE DEFENCE RESEARCH BOARD

53. (1) There shall be a Defence Research Board, which shall carry out such duties in connection with research relating to the defence of Canada and development of or improvements in materiel as the Minister may assign to it, and shall advise the Minister on all matters relating to scientific, technical, and other research and development that in its opinion may affect national defence.

(2) The Defence Research Board consists of a Chairman and a Vice-Chairman, appointed by the Governor in Council, and

(a) the President of the National Research Council of Canada;
1966-67, c. 26, s. 13

(b) the Deputy Minister of National Defence;

(c) such members as may be appointed by the Minister, as ex officio members representing the Canadian Forces; and

(d) such additional members representative of universities, industry and other research interests as the Governor in Council appoints.
1964-65, c. 21, s. 3

(3) The Chairman and Vice-Chairman hold office during pleasure, and shall be paid such salaries as the Governor in Council determines.

(4) The members of the Defence Research Board, other than the Chairman, Vice-Chairman or the ex officio members, hold office for a period not

exceeding three years but are eligible for re-appointment, and shall be paid such remuneration, if any, as the Governor in Council determines.

(5) Each member shall be paid his travelling and other expenses incurred in connection with the work of the Defence Research Board.

(6) The Chairman is the chief executive officer of the Defence Research Board and, under the direction of the Minister and in accordance with policies approved by the Board, shall oversee and direct the officers, clerks and employees of the Board, have general control of the business of the Board, have supervision over the work directed to be carried out by the Board, be charged with the organization, administration and operation of the defence establishments of the Board and perform such other duties as the Minister may assign to him.

(7) The Vice-Chairman shall perform such duties as may be assigned to him under the by-laws made by the Defence Research Board.

54. The Defence Research Board may, with the approval of the Minister,

(a) Notwithstanding the Civil Service Act or any other section of this Act or any other statute or law, appoint and employ the professional, scientific, technical, clerical and other employees required to carry out efficiently the duties of the Board, prescribe their duties and, subject to the approval of the Governor in Council, prescribe their terms of appointment and service and fix their remuneration;

(b) make by-laws or rules for the regulation of its proceedings and for the performance of its functions;

(c) enter into contracts in the name of Her Majesty for research and investigations with respect only to matters relating to defence; and

(d) make grants in aid of research and investigations with respect only to matters relating to defence and establish scholarships for the education or training of persons to qualify them to engage in such research and investigations. 1950, c. 43, s. 54.

55. (1) All expenses of the Defence Research Board shall be paid out of moneys appropriated by Parliament for the purpose or received by the Board through the conduct of its operations, bequests, donations or otherwise and shall be paid by the Minister of Finance on the requisition of the Minister.

(2) The Minister may request the Minister of Finance to allocate any portion of the moneys appropriated by Parliament for the purposes of the Defence Research Board for scholarships or grants in aid of research and investigations, and thereupon the Minister of Finance shall hold that portion of the moneys in trust and may at any time on the requisition of the Minister disburse that portion of the moneys for scholarships or grants in aid of research and investigations.

(3) Any moneys allocated by the Minister of Finance under this section that, in the opinion of the Minister, are not required for the purpose for which they were allocated shall cease to be held in trust. 1950, c. 43, s. 55.

APPENDIX B — ANNEX II

HISTORY AND AIMS OF THE RESEARCH SATELLITE PROGRAM

1. Shortly before the launch of Alouette I, the US suggested to Canada that a joint US/Canadian program of ionospheric research using satellites should be arranged. This suggestion resulted in a memorandum to the Cabinet by the Minister of National Defence entitled "Ionosphere Monitor Satellite Program" dated 7 January, 1963. Following a meeting of the Cabinet on 10 January, 1963, the program was approved. The memorandum to the Cabinet stated that four satellites would be launched, and that the opportunity would be taken to use Canadian industry to the fullest extent in order to up-grade Canada's industrial capability in the space field. These two aims of the program, (a) to launch four satellites and (b) to up-grade Canadian industry, were considered equally important.

2. Following the Cabinet approval, a "Memorandum of Understanding" was drawn up between representatives of the Defence Research Board and the US National Aeronautics and Space Administration (NASA) which outlined each country's responsibility and the way in which the Joint program would be managed. An exchange of notes between the US Ambassador to Canada and the Secretary of State for External Affairs, dated 6 May 1964, approved this Memorandum of Understanding, and also agreed that the agreement could be terminated by mutual consent between the two Governments prior to 1970, and thereafter by either Government upon six months' notice.

3. The program is run by program managers appointed respectively by NASA and DRB, aided by the ISIS Working Group which acts as an advisory body as stipulated in the Memorandum of Understanding. This Working Group has representatives from NASA, DRB, Science Research Council of the UK, and the US National Bureau of Standards as the main participants. As the program has developed, representatives from other nations, Norway, Japan, Australia, and France have become participants by operating ground stations for the acquisition of data from Alouette I and II, and by analyzing the data.

APPENDIX C — ANNEX II

DEFENCE SCIENTIFIC INFORMATION SERVICE

1. At the inception of DRB, the Minister of National Defence assigned to it the responsibility of providing scientific information facilities for the Department's needs. The Defence Scientific Information Service (DSIS) was brought into being to fulfil this responsibility. It carries out the functions of negotiating defence document exchange agreements with friendly countries, of cataloguing and selectively disseminating documentary information so obtained, and of retrieving this information when needed at a later date.

2. These functions are carried out on behalf of all agencies involved in defence research or development. Foreign documents which can be procured only through defence channels are obtained for all Federal agencies requiring them in connection with work being done for defence. A similar function is performed for defence industrial contractors, for research grantees in the universities, and for any other public institutions when required for defence purposes.

3. DSIS monitors the work of similar agencies in the defence departments of friendly countries in the field of information science, and represents the Department in international activities in scientific and technical information, such as the Technical Information Panel of NATO's Advisory Group on Aerospace Research and Development.

APPENDIX D — ANNEX II

A WAY TO RELATE RESEARCH PROJECTS TO MILITARY FUNCTIONS

1. As stated in this Annex an Activity entitled "Defence Research and Preliminary Development" was designated to embrace all critical and exhaustive scientific studies, enquiries and investigations primarily necessary for the discovery and interpretation of new facts and for the application of these to the design of improved materials, equipment or processes and to the solution of other practical problems.

2. DRB is now engaged in developing a method to relate research projects to military functions. The development of such a method is still far from complete but it is likely that it will be based on the concept that technology is the coupler between research and military functions. For example, the results of research on explosives influence military firepower by means of the technology that translates the new knowledge into improved weapons and components. The defence relevance of a research project might, then, be derived by a stepwise process of evaluating its importance to a technology, the importance of the technology to a class of equipment, the importance of the equipment to a military function, and the importance of the military function to the various missions of the Canadian Forces.

3. Charts 1 and 2 show the conceptual framework which relates technology-sensitive aspects of military materiel and functions to the overall operational capability of a military force. Chart 3 shows how this concept was applied to break down the overall Defence Research and Preliminary Development activity into sub-activities and project groups and so provide a clear link between research projects and military functions.

4. In other words the Activity "Research and Preliminary Development" has five sub-activities consisting of:

1.1 Research related to Combat and Active Defence

1.2 Research related to Passive Defence

1.3 Research related to Command and Control

1.4 Research related to Logistics

1.5 Research related to Manpower

5. Each of these sub-activities have a number of groups to which research projects can be assigned on the basis of the technology they will influence and the impact of that technology on military functions. For example a research project on explosives clearly belongs in the project group "Firepower", a component of the sub-activity "Combat and Active Defence".

6. When this methodology is completely developed it will provide a structure for qualitative and quantitative evaluation of the relative importance of diverse research programs and projects vis-a-vis the improvement and maintenance of the operational capability of the Canadian Forces.

CHART 1 — BASIC ELEMENTS OF OPERATIONAL CAPABILITY

Operational Capability

(The ability to carry on combat operations including movement, supply, attack, defence and manoeuvres needed to gain the objectives of any battle or campaign).

Capability Elements

1. *Combat and Active Defence*
   (Actions taken to destroy or reduce the effectiveness of enemy force or to gain advantage over the enemy).
2. *Passive Defence*
   (Defence of a place without the employment of active weapons and without the expectation of taking the initiative).
3. *Command and Control*
   (The acquisition, processing and dissemination of information for the planning, directing and controlling of operations by a commander).
4. *Logistics*
   (The determination of requirements, acquisition, storage, movement, distribution, maintenance and disposal of material; the movement of personnel; the operation of material support facilities; the acquisition or furnishing of supply service; field accommodation).
5. *Manpower*
   (The provision and efficient use of manpower).

CHART 2 — RELATIONSHIP OF TECHNOLOGY TO MILITARY CAPABILITIES

Capability Elements	Functional Sub-elements	Some Technology-dependent Aspects of Sub-elements*
1. *Combat and Active Defence* (Actions taken to destroy or reduce the effectiveness of enemy forces or to gain some advantages over the enemy).	1.1 Firepower	- Weapons, components and associated fire control systems, armament (including body armour) - Weapon vulnerability - Explosives
	1.2 Tactical Mobility (within battle area).	- Combat vehicles (tanks, aircraft, ships, submarines) - Personnel carriers (armoured & unarmoured (land, sea & air including tactical air transport)) - Vehicle vulnerability - Defeat of barriers (tactical bridging, mine clearance (including diving equipment & procedures))
2. *Passive Defence* (Defence of a *place* without the employment of active weapons and without the expectation of taking the initiative).	2.1 Fortifications	- Trenches - Walls - Construction equipment and materials - Shielding
	2.2 Concealment & Deception	- Screening agents and smoke - Camouflage - Electromagnetic and electronic countermeasures for purposes of deception
	2.3 Barriers	- Mines - Artificial physical barriers

* The items in this column are those aspects whose military qualities e.g. performance efficiency, economy, effectiveness, etc. are or may be *directly* influenced by technological factors. Other aspects such as strategy, tactics, organization, etc. that are influenced *indirectly* by technological factors (e.g. as a result of technological changes in the tools of war) are excluded from this column. This list is illustrative, not comprehensive.

CHART 2 — RELATIONSHIP OF TECHNOLOGY TO MILITARY CAPABILITIES (Cont'd)

Capability Elements	Functional Sub-elements	Some Technology-dependent Aspects of Sub-elements
3. *Command and Control* (The acquisition, processing and dissemination of information for the planning, directing and controlling of operations by a commander).	3.1 Surveillance (The systematic observation of air, surface or subsurface areas by visual, electronic, photographic or other means for intelligence purposes).	- Optical, infrared, radar, acoustic and magnetic equipment and components - Detection and identification - Search and rescue equipment and aids - Data and signal processing equipment for surveillance and reconnaissance systems - Electronic counter-counter measures
	3.2 Reconnaissance (A mission undertaken to obtain information by visual observation or other methods).	- Same as in 3.1
	3.3 Navigation	- Navigation systems, equipment and components
	3.4 Communications	- Communications systems, equipment and components including data processing equipment for communications systems - Voice communications
	3.5 Data processing (non specific).	- Non-specific data processing, information display, and signal detection equipment and methods - Data processing for command purposes

NOTE: *Intelligence* — The product resulting from the collection, evaluation, analysis, integration and interpretation of all available information which concerns one or more aspects of foreign nations or areas of operation and which is immediately or potentially significant to military operations.

CHART 2 — RELATIONSHIP OF TECHNOLOGY TO MILITARY CAPABILITIES (Cont'd)

Capability Elements	Functional Sub-elements	Some Technology-dependent Aspects of Sub-elements
4. *Logistics* (The determination of requirements, acquisition, storage, movement, distribution, maintenance and disposal of materiel; the movement of personnel; the operation of materiel support facilities; the acquisition or furnishing of supply services; field accommodation)	4.1 Materiel supply and movement (The supply and transport of all movable public property (except money) provided for any purpose under the NDA and includes any vessel, vehicle, aircraft, animal, missile, arms, ammunition, clothing, stores provisions or equipment so provided).	- Ships - Vehicles - Aircraft - Pipelines, etc. - Containers & packaging - Power Sources - Strategic mobility (i.e. home base→operational base)
	4.2 Maintenance and Repair	- Materials and methods - Corrosion - Equipment and instruments
	4.3 Movement of Personnel	- Ships, Vehicles, Aircraft - Power sources
	4.4 Medical logistic support (Medical care, treatment, hospitalization, evacuation, furnishing of medical services, supplies, materiel, and adjuncts, thereto).	- Conventional medical and military medical equipment, supplies and procedures - NBCW prophylaxis and therapy

CHART 2 — RELATIONSHIP OF TECHNOLOGY TO MILITARY CAPABILITIES (Cont'd)

Capability Elements	Functional Sub-elements	Some Technology-dependent Aspects of Sub-elements
4. *Logistics* (Cont'd) (The determination of requirements, acquisition, storage, movement, distribution, maintenance and disposal of materiel; the movement of personnel; the operation of materiel support facilities; the acquisition or furnishing of supply services; field accommodation).	4.5 Environmental protection (Protection against the injurious effects of natural and artificial environments (e.g. habitability) but excluding hazards clearly attributable to enemy action, equipment malfunctions and specialist environments).	- Equipment - General clothing
	4.6 Damage prevention and limitation (The prevention or limitation of *secondary* damage to materiel resulting from hazards attributable to enemy action, equipment malfunction or specialist environment).	

CHART 2 — RELATIONSHIP OF TECHNOLOGY TO MILITARY CAPABILITIES (Cont'd)

Capability Elements	Functional Sub-elements	Some Technology-dependent Aspects of Sub-elements
5. *Manpower* (The provision and efficient use of manpower).	5.1 Use of Manpower	- Machines in place of men - Use of computers
	5.2 Training	- Training principles and methodology - Training aids and stores
	5.3 Human Performance (of healthy personnel).	- Environmental and equipment effects on performance - Work routines - Toxic hazards
	5.4 Personnel protection and safety (Protection against hazards clearly attributable to enemy action, equipment malfunction and specialist environments. Excludes armour (see Firepower) detection aspects of search and rescue (see Surveillance and Reconnaissance) and hazards of natural and artificial environments (see Materiel Supply and Movement and Environmental Protection).	- Escape equipment and procedures - Survival equipment, clothing, procedures and rations

CHART 3 — THE STRUCTURE OF THE ACTIVITY "DEFENCE RESEARCH AND PRELIMINARY DEVELOPMENT"

Activity	Sub-Activity	Project Group
1. Defence Research and Preliminary Development	1.1 Combat and Active Defence	1.1.1 Firepower
		1.1.2 Tactical Mobility
	1.2 Passive Defence	1.2.1 Fortifications
		1.2.2 Concealment and Deception
	1.3 Command and Control	1.3.1 Surveillance and Reconnaissance
		1.3.4 Communications
		1.3.5 Data Processing
	1.4 Logistics	1.4.1 Materiel Supply
		1.4.2 Maintenance and Repair
		1.4.3 Medical Support
		1.4.5 Environmental Protection
	1.5 Manpower	1.5.2 Selection and Training
		1.5.3 Human Performance
		1.5.4 Personnel Protection and Safety

ANNEX III - PERSONNEL POLICIES

GENERAL

1. The National Defence Act, as amended to 1967, specifies that "The Defence Research Board may, with the approval of the Minister,

(a) Notwithstanding the Civil Service Act or any other section of this Act or any other statute or law, appoint and employ the professional, scientific, technical, clerical and other employees required to carry out efficiently the duties of the Board, prescribe their duties and, subject to the approval of the Governor in Council, prescribe their terms of appointment and service and fix their remuneration".

2. DRB makes every effort to employ first class scientists of proven ability. To obtain them in the face of the severe competition that characterizes professional recruitment today, it must recruit efficiently, ensure good working conditions with competitive remuneration and offer attractive careers in both research and administration. In practice the Board works closely and harmoniously with the National Research Council and the Public Service Commission with respect to grades and salary scales but is independent in the exercise of judgment with respect to individual scientists.

3. The Selection Committee of the Defence Research Board is the body created to exercise this independent judgment. Its terms of reference state that it is to examine the qualifications of all applicants for employment by DRB, to recommend to the Board the candidate considered most suitable for a position and, furthermore to examine the qualifications of employees for promotion and make recommendations for promotion.

4. The Chairman and Members of the Committee may be selected from universities, industry and other government agencies. Members of the Selection Committee are recommended by the Chairman and submitted to the Board for approval. The Chief of Personnel is the Secretary. The Committee reports to the Chairman, Defence Research Board.

5. The current membership of the Selection Committee is as follows:

CHAIRMAN:	Mr. J.D. Houlding	President and Director, RCA Victor Company Limited.
MEMBERS:	Dr. A.B. van Cleave	Chairman, Division of Natural Science, University of Saskatchewan.
	Dr. H.E. Duckworth	Vice-President (Academic), University of Manitoba.
	Dr. W.G. Biglow	Associate Professor of Surgery, University of Toronto, Senior Surgeon and Head, Division of Cardiovascular Surgery, Toronto General Hospital.
	Dr. H.H. Kerr	Chairman, Ontario Council of Regents for Colleges of Applied Arts and Technology, Toronto.
	Prof. Maurice L'Abbé	Vice-Rector, University of Montreal.
	Prof. Napoleon LeBlanc	Vice-Rector, University of Laval, Québec.

(These are all members of the Defence Research Board).

RECRUITMENT OF SCIENTISTS

6. The Chief of Personnel has on his staff three personnel officers who devote about half their time to recruitment of scientists. Literature describing the research program of the Defence Research Board is made available annually to graduating students through university placement officers. Students showing interest are interviewed by DRB representatives, and applications for employment are sought from those who appear suitable. Employment offers are usually restricted to students who are judged finally by the Selection Committee (para 2) to be in the top quarter of their classes as evidenced by class records and faculty appraisals. In some cases appraisal of students for full-time employment is assisted by the prior opportunity to assess them in summer work at DRB establishments.

CRITERIA FOR RESEARCHERS

7. No research has been undertaken to develop special criteria or selection methods for use in recruitment of defence scientists, since there has been little indication that the quality of those hired leaves much to be desired in general. Particular interest has, however, been taken in systematic improvement in the methods of appraising the achievement of scientists after employment. Rating and other assessment techniques have been examined, and an analysis of the volume of production of patents, reports and publications and patents by individuals and groups has been made.

IDENTIFICATION OF POTENTIAL RESEARCH ADMINISTRATORS

8. Current procedures call for an annual review of each scientist's progress and development. This includes consideration of his managerial potential. Since there are successive levels of management responsibility, from section leadership through division direction up to the general management of a research station, opportunity exists to view the effectiveness of the individual at the junior stages, often in more than one establishment, before he is considered for a more senior appointment.

DISTINCTIONS BETWEEN RESEARCHERS AND RESEARCH ADMINISTRATORS

9. Both research workers and research administrators are graded and paid on the same scale. It is therefore quite possible for a scientist to be promoted to the most senior level on the ground of scientific prowess alone. In practice, however, it is very rare for an individual to attain on this basis a level equivalent to that of director general of an establishment; it is less uncommon for him to reach the pay level immediately below this. There is, therefore, an incentive for the scientist to undertake management responsibilities.

ADDITIONAL EDUCATION OF STAFF

10. Encouragement is given to the acquisition of additional academic training by defrayment of one-half of the fees incurred for relevant evening courses. Individuals are also sent from time to time on short courses which will benefit their work directly, and full expenses are paid. Up to 15 scientists may be given longer term educational leave at any one time for the purpose of attaining a higher degree level and are assisted by provision of scholarships amounting

to 40 to 60 per cent of normal salary, together with payment of part or all of travel expenses and university fees. Most establishments hold seminars from time to time on relevant scientific issues or programs and outside participants may be invited. Mature scientists who after some years' work, especially on applied problems, exhibit a need for refreshment or extension of their knowledge, may be sent away for periods of approximately one year's additional training on full salary.

ANNEX IV — REGIONAL DISTRIBUTION OF ACTIVITIES

1. Regional Pattern of Expenditures. The regional pattern of the Board's expenditures by provinces for the past five years is shown in Table 1.

2. The figures include all capital and operating expenses of the Board according to the province in which they are located, and the locations of the universities and the industrial firms in receipt of grants under the extra mural research grants program to universities and the Defence Industrial Research Program. The expenditures for the Research Satellite Program are also included.

3. Board expenditures occur in all the provinces except Prince Edward Island and the distribution is strongly influenced by the geographical distribution of the research establishments i.e. Nova Scotia (1), Quebec (1), Ontario (4), Alberta (1), British Columbia (1).

4. Regional Factors. The regional distribution of the Board's scientific activities came about partly through its having taken over existing military research establishments in Nova Scotia, Quebec, Ontario and Alberta in 1947, and partly because of the need for work in particular geographical environments. For instance, the east and west coasts are particularly suited for research related to anti-submarine warfare, the Arctic and Sub-arctic for the arctic aspects of anti-submarine warfare, effects of the aurora on telecommunications, and problems associated with military operations under arctic conditions. Similarly the highly industrialized provinces of Ontario and Quebec are particularly suited to applied research in fields in which Canadian industrial participation is needed in the applied research phases or will be needed in the subsequent development of equipment and components e.g. telecommunications, satellites, protective clothing, batteries, explosives, radiation instruments.

5. In effect, therefore, it can be said that defence problems require scientific activities to be carried out in certain regions of the country. Consequently, although DRB has no statutory role in contributing to regional

development, it could not operate effectively except by distributing its scientific activities across the country and hence it has contributed to some extent to regional development.

6. Benefits and Costs of Regional Distribution. The benefits of regional distribution of its scientific activities are numerous both to DRB and the regions involved. It has fostered close relationships with universities, industries and other research institutions in all provinces with the result that we have the benefit of their knowledge and expertise and they have more knowledge of defence science in general and the Board's interests in particular than would be the case otherwise. Such relationships assist in the recruitment of professional staff and this, in turn, means that the Board's staff consists of representatives of all parts of Canada. The mobility of staff within the Board means that as persons move from province to province, they develop a broad awareness and understanding of the many facets of national defence and, because families move as well, the regional distribution of scientific activities makes a contribution to the growth of a sense of national identity and unity. Another benefit of regional distribution is that it fosters close relationships with operational commands and units of the Canadian Forces. Such relationships are very effective in ensuring that laboratory scientists appreciate the problems, environment and viewpoints of their colleagues in the Forces and thereby have a significant influence on the value and effectiveness of the scientific activities.

7. Among the costs of regional distribution has been that of increased overhead owing to the need for local management and administrative staff to support the research effort in widely separated localities. Another cost is that of transfers of scientists from one station to another in a different city or province in the interest of the development of careers and in order best to meet the Board's current staff requirements. Such geographical transfers of scientists, together with their families and belongings, which would not have been required if all the DRB technical establishments were concentrated in say, the Ottawa region, have averaged about 9 per annum. This is approximately 1½ per cent of the total number of scientists employed.

Distribution by fiscal years is as follows:

1963-64	7
1964-65	6
1965-66	11
1966-67	9
1967-68	12
1968-69 (to date)	8

Another intangible cost is the increased effort that is needed to ensure effective communication and coordination between the central organization and its parts and between the parts themselves. Some of these latter costs are reflected in travel budgets.

8. It is clear, however, that the benefits far outweigh the costs so far as DRB is concerned.

TABLE 1 — Regional Pattern of Expenditures (in thousands of dollars)

		B.C.	ALTA.	SASK.	MAN.	ONT.	QUE.	N.B.	N.S.	NFLD.	TOTAL
1963-64	Intramural	1,051	3,152	443	262	13,430	7,778		2,192		
	Industry	36	100		-	1,698	1,533		25		
	University	189	90	126	64	892	458	7	67		
	TOTAL	1,276	3,342	569	326	16,020	9,769	7	2,284		33,593
1964-65	Intramural	1,079	3,219	303	222	13,947	7,708		2,027		
	Industry		114		21	2,666	3,593		21		
	University	177	72	87	68	835	530	20	73		
	TOTAL	1,256	3,405	390	311	17,448	11,831	20	2,121		36,782
1965-66	Intramural	1,253	3,751	379	55	14,945	8,463		2,447		
	Industry	34	417		7	3,540	4,269		16		
	University	205	71	115	49	949	555	24	87		
	TOTAL	1,492	4,239	494	111	19,434	13,287	24	2,550		41,631
1966-67	Intramural	1,540	4,142	395		14,751	9,306		2,582		
	Industry		544		4	2,989	5,478		-		
	University	277	77	121	63	1,170	608	38	104		
	TOTAL	1,817	4,763	516	67	18,910	15,392	38	2,686		44,189
1967-68	Intramural	2,145	4,198	125		16,464	9,666		3,257		
	Industry		415		1	2,764	4,803		-		
	University	318	213	129	96	1,291	681	32	58	5	
	Ship Construction	3,701									
	TOTAL	6,164	4,826	254	97	20,519	15,150	32	3,315	5	50,362
	GRAND TOTAL	12,005	20,575	2,223	912	92,331	65,429	121	12,956	5	206,557

ANNEX V - PERSONNEL STATISTICS

1. In the following Tables, statistical data is supplied for the Defence Research Board as a whole, for each of the establishments (which are the units of the Board that conduct scientific activities) and for all other personnel.

2. The "Others" category includes the personnel in all the organizational units shown on the DRB Organization Chart in Annex 1, with the exception of the establishments, and the personnel seconded to units of the Canadian Forces. In Table 3, the data for these personnel is grouped on a functional basis as follows:

(a) Management and Planning. This includes all senior management and the scientific staffs which support them in program planning and administration.

(b) Personnel and Financial Administration. This consists of the staffs of the Chief of Personnel and the Comptroller.

(c) Scientific Liaison. This consists of the staffs seconded to Canadian Forces Headquarters and those of the London and Washington offices.

(d) Scientific Information Service. This consists of the staff of DSIS (Defence Scientific Information Service).

(e) Scientific Intelligence. This consists of the group of scientists seconded to the Canadian Forces to provide scientific study and analysis of intelligence material.

TABLE 1 — Current Personnel Establishment and Strengths (1 July, 1968)

	DRAE		CARDE		DRES		DREA		DREP		DRET		DRTE		DCBRE		ALL OTHERS		TOTAL	
	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.	EST.	EMP.
Professional	70	63	122	122	38	39	56	53	32	32	35	30	116	113	53	49	88	89	610	590
Technical	4	4	322	319	125	125	101	103	50	49	46	45	170	178	90	84	11	11	919	918
Workers	–	–	120	116	90	90	15	14	7	7	19	19	56	56	11	11	–	–	318	313
Other Support Personnel	28	24	129	120	73	73	26	28	15	15	32	32	81	81	30	32	240	228	654	633
Others not included in above (House-keeping duties)	–	–	47	47	71	74	13	13	–	–	8	8	33	33	–	–	9	9	181	184
On Loan	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	1	–	6
Seconded Personnel	–	2	–	3	–	6	–	3	–	2	–	–	–	6	–	4	–	1	–	27
Contract Personnel	–	–	–	39	–	6	–	7	–	–	–	5	–	19	–	–	–	5	–	81

TABLE 2 — Number of Professionals Mostly Engaged in Executive and Administrative Duties

Defence Research Analysis Establishment	2
Canadian Armament Research and Development Establishment	15
Defence Research Establishment Suffield	5
Defence Research Establishment Atlantic	6
Defence Research Establishment Pacific	4
Defence Research Establishment Toronto	4
Defence Research Telecommunications Establishment	12
Defence Chemical, Biological and Radiation Establishment	6
All Others	40
TOTAL	94

TABLE 3 — Educational and Experience Data For Professional Staff

A — DEFENCE RESEARCH BOARD (SUMMARY)

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Canada	159	169		169
Great Britain	54	49		48
Other Commonwealth	4	3		2
USA	2	-		3
Europe	2	2		1
South America	1	-		-
Asia	1	-		-
Mean Number of Years Since Bachelor Graduation			—	20
Mean Number of Years Employed by DRB			—	13
Mean Age			—	46
Per Cent Effective in Both Official Languages			—	26
MASTER DEGREE				
Canada	150	166		149
Great Britain	22	16		16
Other Commonwealth	4	3		1
USA	5	-		18
Europe	4	-		1
Mean Number of Years Since Bachelor Graduation			—	15
Mean Number of Years Employed by DRB			—	12
Mean Age			—	43
Per Cent Effective in Both Official Languages			—	21
DOCTOR DEGREE				
Canada	122	130		98
Great Britain	23	20		38
Other Commonwealth	9	9		3
USA	6	3		22
Europe	3	1		2
Mean Number of Years Since Bachelor Graduation			—	15
Mean Number of Years Employed by DRB			—	13
Mean Age			—	44
Per Cent Effective in Both Official Languages			—	17
Per Cent Employed by Industry			—	24.2
Per Cent Employed by Universities			—	8.3
Per Cent Employed by Provincial Departments or Agencies			—	1.8
Per Cent Employed by Other Federal Government Agencies			—	16.3
Per Cent Employed by Other Governments			—	7.8
Per Cent Effective in Both Official Languages			—	22.0

TABLE 3 — Educational and Experience Data For Professional Staff (Cont'd)

B — DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	20	22	21
Great Britain	4	3	3
USA	-	-	1
South America	1	-	-

Mean Number of Years Since Bachelor Graduation	—	13
Mean Number of Years Employed by DRB	—	10
Mean Age	—	40
Per Cent Effective in Both Official Languages	—	0

MASTER DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	15	19	20
Great Britain	4	2	-
Other Commonwealth	1	-	-
USA	-	-	1
Europe	1	-	-

Mean Number of Years Since Bachelor Graduation	—	12
Mean Number of Years Employed by DRB	—	9
Mean Age	—	41
Per Cent Effective in Both Official Languages	—	0

DOCTOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	4	4	5
Great Britain	-	-	1
Other Commonwealth	2	2	-

Mean Number of Years Since Bachelor Graduation	—	14
Mean Number of Years Employed by DRB	—	14
Mean Age	—	41
Per Cent Effective in Both Official Languages	—	0

Per Cent Employed by Industry	—	26.4
Per Cent Employed by Universities	—	7.5
Per Cent Employed by Provincial Departments or Agencies	—	1.8
Per Cent Employed by Other Federal Government Agencies	—	16.9
Per Cent Employed by Other Governments	—	3.6
Per Cent Effective in Both Official Languages	—	0.0

TABLE 3—Educational and Experience Data For Professional Staff (Cont'd)

C — CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	49	50	49
Great Britain	8	10	10
Other Commonwealth	1	-	-
USA	1	-	1
Europe	1	1	1
Asia	1	-	-

Mean Number of Years Since Bachelor Graduation	—	13
Mean Number of Years Employed by DRB	—	10
Mean Age	—	39
Per Cent Effective in Both Official Languages	—	77

MASTER DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	27	28	26
Great Britain	5	5	4
Other Commonwealth	1	1	—
USA	-	-	3
Europe	1	-	1

Mean Number of Years Since Bachelor Graduation	—	10
Mean Number of Years Employed by DRB	—	9
Mean Age	—	35
Per Cent Effective in Both Official Languages	—	96

DOCTOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	23	23	21
Great Britain	3	3	3
Other Commonwealth	1	1	1
USA	-	-	1
Europe	-	-	1

Mean Number of Years Since Bachelor Graduation	—	10
Mean Number of Years Employed by DRB	—	9
Mean Age	—	39
Per Cent Effective in Both Official Languages	—	54

Per Cent Employed by Industry	—	22.1
Per Cent Employed by Universities	—	4.9
Per Cent Employed by Provincial Departments or Agencies	—	4.9
Per Cent Employed by Other Federal Government Agencies	—	7.3
Per Cent Employed by Other Governments	—	4.0
Per Cent Effective in Both Official Languages	—	75.0

TABLE 3 — Educational and Experience Data For Professional Staff (Cont'd)

D — DEFENCE RESEARCH ANALYSIS ESTABLISHMENT

BACHELOR DEGREE			
Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	19	19	19
Great Britain	10	10	11
Other Commonwealth	2	2	1
USA	-	-	1
Europe	1	1	-
Mean Number of Years Since Bachelor Graduation		—	16
Mean Number of Years Employed by DRB		—	9
Mean Age		—	43
Per Cent Effective in Both Official Languages		—	10
MASTER DEGREE			
Canada	16	18	16
Great Britain	4	3	4
USA	1	-	1
Mean Number of Years Since Bachelor Graduation		—	14
Mean Number of Years Employed by DRB		—	10
Mean Age		—	38
Per Cent Effective in Both Official Languages		—	0
DOCTOR DEGREE			
Canada	10	10	7
Great Britain	-	-	3
Mean Number of Years Since Bachelor Graduation		—	15
Mean Number of Years Employed by DRB		—	12
Mean Age		—	44
Per Cent Effective in Both Official Languages		—	0
Per Cent Employed by Industry		—	30.0
Per Cent Employed by Universities		—	11.1
Per Cent Employed by Provincial Departments or Agencies		—	1.5
Per Cent Employed by Other Federal Government Agencies		—	22.2
Per Cent Employed by Other Governments		—	20.5
Per Cent Effective in Both Official Languages		—	5.0

TABLE 3 — Educational and Experience Data For Professional Staff (Cont'd)

E — DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT

Country	Of Birth	Of Secondary Education		Of Higher Education
BACHELOR DEGREE				
Canada	25	26		26
Great Britain	9	8		8
Mean Number of Years Since Bachelor Graduation			—	16
Mean Number of Years Employed by DRB			—	11
Mean Age			—	42
Per Cent Effective in Both Official Languages			—	0
MASTER DEGREE				
Canada	40	41		35
Great Britain	5	4		6
USA	-	-		4
Mean Number of Years Since Bachelor Graduation			—	9
Mean Number of Years Employed by DRB			—	8
Mean Age			—	44
Per Cent Effective in Both Official Languages			—	5
DOCTOR DEGREE				
Canada	24	26		19
Great Britain	4	4		11
Other Commonwealth	3	3		-
USA	-	-		3
Europe	2	1		1
South America	1	-		-
Mean Number of Years Since Bachelor Graduation			—	11
Mean Number of Years Employed by DRB			—	11
Mean Age			—	42
Per Cent Effective in Both Official Languages			—	12

Per Cent Employed by Industry	—	18.5
Per Cent Employed by Universities	—	7.0
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	10.6
Per Cent Employed by Other Governments	—	8.8
Per Cent Effective in Both Official Languages	—	8.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

F — DEFENCE CHEMICAL, BIOLOGICAL AND RADIATION ESTABLISHMENT

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Canada	3	5		5
Great Britain	6	4		4
Mean Number of Years Since Bachelor Graduation			—	23
Mean Number of Years Employed by DRB			—	15
Mean Age			—	47
Per Cent Effective in Both Official Languages			—	0
MASTER DEGREE				
Canada	10	10		8
Other Commonwealth	1	1		1
USA	-	-		2
Mean Number of Years Since Bachelor Graduation			—	18
Mean Number of Years Employed by DRB			—	15
Mean Age			—	45
Per Cent Effective in Both Official Languages			—	10
DOCTOR DEGREE				
Canada	20	22		19
Great Britain	5	5		6
Other Commonwealth	1	1		1
USA	2	-		3
Europe	1	1		-
Mean Number of Years Since Bachelor Graduation			—	15
Mean Number of Years Employed by DRB			—	13
Mean Age			—	37
Per Cent Effective in Both Official Languages			—	20
Per Cent Employed by Industry			—	30.6
Per Cent Employed by Universities			—	8.1
Per Cent Employed by Provincial Departments or Agencies			—	0.0
Per Cent Employed by Other Federal Government Agencies			—	10.2
Per Cent Employed by Other Governments			—	6.1
Per Cent Effective in Both Official Languages			—	15.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

G — DEFENCE RESEARCH ESTABLISHMENT TORONTO

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Great Britain	1	1		1
Mean Number of Years Since Bachelor Graduation			—	22
Mean Number of Years Employed by DRB			—	10
Mean Age			—	41
Per Cent Effective in Both Official Languages			—	25

MASTER DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Canada	3	3		3
Other Commonwealth	1	1		-
USA	-	-		1
Mean Number of Years Since Bachelor Graduation			—	9
Mean Number of Years Employed by DRB			—	8
Mean Age			—	34
Per Cent Effective in Both Official Languages			—	0

DOCTOR DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Canada	8	11		6
Great Britain	5	2		2
Other Commonwealth	1	1		-
USA	1	1		7
Mean Number of Years Since Bachelor Graduation			—	8
Mean Number of Years Employed by DRB			—	6
Mean Age			—	43
Per Cent Effective in Both Official Languages			—	0

Per Cent Employed by Industry	—	10.0
Per Cent Employed by Universities	—	13.3
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	16.6
Per Cent Employed by Other Governments	—	10.0
Per Cent Effective in Both Official Languages	—	3.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

H — DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	3	4	5
Great Britain	6	5	4
Mean Number of Years Since Bachelor Graduation		—	23
Mean Number of Years Employed by DRB		—	11
Mean Age		—	52
Per Cent Effective in Both Official Languages		—	0
MASTER DEGREE			
Canada	17	17	14
USA	-	-	3
Mean Number of Years Since Bachelor Graduation		—	15
Mean Number of Years Employed by DRB		—	10
Mean Age		—	45
Per Cent Effective in Both Official Languages		—	7
DOCTOR DEGREE			
Canada	10	11	7
Great Britain	2	1	1
USA	1	1	5
Mean Number of Years Since Bachelor Graduation		—	14
Mean Number of Years Employed by DRB		—	10
Mean Age		—	46
Per Cent Effective in Both Official Languages		—	0

Per Cent Employed by Industry	—	25.0
Per Cent Employed by Universities	—	10.2
Per Cent Employed by Provincial Departments or Agencies	—	5.1
Per Cent Employed by Other Federal Government Agencies	—	15.4
Per Cent Employed by Other Governments	—	7.6
Per Cent Effective in Both Official Languages	—	2.5

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

I — DEFENCE RESEARCH ESTABLISHMENT PACIFIC

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	11	12	11
Great Britain	1	-	1
Other Commonwealth	1	1	1

Mean Number of Years Since Bachelor Graduation	—	18
Mean Number of Years Employed by DRB	—	11
Mean Age	—	46
Per Cent Effective in Both Official Languages	—	0

MASTER DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	8	11	10
USA	2	-	1
Europe	1	-	-

Mean Number of Years Since Bachelor Graduation	—	16
Mean Number of Years Employed by DRB	—	14
Mean Age	—	42
Per Cent Effective in Both Official Languages	—	0

DOCTOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	8	8	5
Great Britain	1	1	4

Mean Number of Years Since Bachelor Graduation	—	15
Mean Number of Years Employed by DRB	—	12
Mean Age	—	39
Per Cent Effective in Both Official Languages	—	0

Per Cent Employed by Industry	—	30.3
Per Cent Employed by Universities	—	6.6
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	27.2
Per Cent Employed by Other Governments	—	0.0
Per Cent Effective in Both Official Languages	—	0.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

J — MANAGEMENT AND PLANNING

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	8	8	9
Great Britain	4	4	3

Mean Number of Years Since Bachelor Graduation	—	25
Mean Number of Years Employed by DRB	—	15
Mean Age	—	52
Per Cent Effective in Both Official Languages	—	17

MASTER DEGREE

Canada	6	7	6
Great Britain	3	2	2
USA	-	-	1

Mean Number of Years Since Bachelor Graduation	—	23
Mean Number of Years Employed by DRB	—	17
Mean Age	—	51
Per Cent Effective in Both Official Languages	—	0

DOCTOR DEGREE

Canada	5	6	4
Great Britain	3	3	4
USA	2	1	2

Mean Number of Years Since Bachelor Graduation	—	18
Mean Number of Years Employed by DRB	—	14
Mean Age	—	48
Per Cent Effective in Both Official Languages	—	40

Per Cent Employed by Industry	—	22.6
Per Cent Employed by Universities	—	16.1
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	29.0
Per Cent Employed by Other Governments	—	16.1
Per Cent Effective in Both Official Languages	—	19.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

K — PERSONNEL AND FINANCIAL ADMINISTRATION

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education		Of Higher Education
Canada	9	10		10
USA	1	-		-
Mean Number of Years Since Bachelor Graduation			—	24
Mean Number of Years Employed by DRB			—	17
Mean Age			—	52
Per Cent Effective in Both Official Languages			—	10
MASTER DEGREE				
Canada	2	2		2
Mean Number of Years Since Bachelor Graduation			—	13
Mean Number of Years Employed by DRB			—	3
Mean Age			—	40
Per Cent Effective in Both Official Languages			—	50
DOCTOR DEGREE				
Canada	2	1		2
Great Britain	-	1		-
Mean Number of Years Since Bachelor Graduation			—	30
Mean Number of Years Employed by DRB			—	20
Mean Age			—	58
Per Cent Effective in Both Official Languages			—	0
Per Cent Employed by Industry			—	42.8
Per Cent Employed by Universities			—	21.4
Per Cent Employed by Provincial Departments or Agencies			—	0.0
Per Cent Employed by Other Federal Government Agencies			—	28.5
Per Cent Employed by Other Governments			—	0.0
Per Cent Effective in Both Official Languages			—	14

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

L — SCIENTIFIC INFORMATION

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	4	5	5
Great Britain	3	2	2

Mean Number of Years Since Bachelor Graduation	—	25
Mean Number of Years Employed by DRB	—	16
Mean Age	—	50
Per Cent Effective in Both Official Languages	—	29

MASTER DEGREE

Canada	1	2	2
USA	1	-	-

Mean Number of Years Since Bachelor Graduation	—	19
Mean Number of Years Employed by DRB	—	19
Mean Age	—	51
Per Cent Effective in Both Official Languages	—	0

DOCTOR DEGREE

Other Commonwealth	1	1	1

Mean Number of Years Since Bachelor Graduation	—	11
Mean Number of Years Employed by DRB	—	11
Mean Age	—	46
Per Cent Effective in Both Official Languages	—	100

Per Cent Employed by Industry	—	45.4
Per Cent Employed by Universities	—	9.0
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	18.1
Per Cent Employed by Other Governments	—	0.0
Per Cent Effective in Both Official Languages	—	30.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

M — SCIENTIFIC LIAISON

Country	Of Birth	Of Secondary Education		Of Higher Education
BACHELOR DEGREE				
Canada	5	5		5
Great Britain	4	4		4
Mean Number of Years Since Bachelor Graduation			—	23
Mean Number of Years Employed by DRB			—	17
Mean Age			—	49
Per Cent Effective in Both Official Languages			—	11
MASTER DEGREE				
Canada	3	5		4
Great Britain	1	–		–
USA	1	–		1
Mean Number of Years Since Bachelor Graduation			—	20
Mean Number of Years Employed by DRB			—	18
Mean Age			—	49
Per Cent Effective in Both Official Languages			—	20
DOCTOR DEGREE				
Canada	7	7		4
Great Britain	–	–		2
USA	–	–		1
Mean Number of Years Since Bachelor Graduation			—	19
Mean Number of Years Employed by DRB			—	17
Mean Age			—	48
Per Cent Effective in Both Official Languages			—	29
Per Cent Employed by Industry			—	23.8
Per Cent Employed by Universities			—	4.8
Per Cent Employed by Provincial Departments or Agencies			—	4.8
Per Cent Employed by Other Federal Government Agencies			—	28.5
Per Cent Employed by Other Governments			—	9.5
Per Cent Effective in Both Official Languages			—	19.0

TABLE 3 — Educational and Experience Data for Professional Staff (Cont'd)

N — SCIENTIFIC INTELLIGENCE

BACHELOR DEGREE

Country	Of Birth	Of Secondary Education	Of Higher Education
Canada	3	3	3

Mean Number of Years Since Bachelor Graduation	—	23
Mean Number of Years Employed by DRB	—	17
Mean Age	—	48
Per Cent Effective in Both Official Languages	—	33

MASTER DEGREE

Canada	2	3	3
Europe	1	-	-

Mean Number of Years Since Bachelor Graduation	—	19
Mean Number of Years Employed by DRB	—	14
Mean Age	—	46
Per Cent Effective in Both Official Languages	—	0

DOCTOR DEGREE

Canada	1	1	-
Great Britain	-	-	1

Mean Number of Years Since Bachelor Graduation	—	13
Mean Number of Years Employed by DRB	—	13
Mean Age	—	41
Per Cent Effective in Both Official Languages	—	0

Per Cent Employed by Industry	—	14.2
Per Cent Employed by Universities	—	0.0
Per Cent Employed by Provincial Departments or Agencies	—	0.0
Per Cent Employed by Other Federal Government Agencies	—	57.1
Per Cent Employed by Other Governments	—	0.0
Per Cent Effective in Both Official Languages	—	14.0

TABLE 4 – Professional Strengths by Degree 1962-68

	I DOCTORATES						
	1962	1963	1964	1965	1966	1967	1968
DRAE	7	6	5	6	8	8	9
CARDE	23	20	19	22	26	28	26
DRES	14	14	16	15	17	15	15
DREA	14	14	13	10	10	10	8
DREP	8	8	8	8	6	5	6
DRET	22	22	21	22	25	27	22
DRTE	29	27	29	31	30	33	34
DCBRE	28	29	31	31	32	33	30
DRNL	1	1	1	–	–	–	–
OTHERS	29	29	28	25	30	20	22
	II MASTERS						
	1962	1963	1964	1965	1966	1967	1968
DRAE	20	19	21	21	22	21	23
CARDE	30	30	33	31	34	33	33
DRES	7	8	9	13	15	15	15
DREA	13	14	18	18	18	22	21
DREP	12	13	13	11	11	12	13
DRET	6	5	7	6	4	4	4
DRTE	20	22	23	32	36	44	43
DCBRE	11	12	10	14	14	13	13
DRNL	1	1	1	–	–	–	–
OTHERS	30	28	30	26	23	21	20
	III BACHELORS						
	1962	1963	1964	1965	1966	1967	1968
DRAE	29	29	28	31	30	29	27
CARDE	53	49	47	42	52	52	55
DRES	9	10	9	9	9	8	9
DREA	17	16	15	22	24	23	24
DREP	10	10	10	11	12	12	12
DRET	2	2	2	3	2	4	5
DRTE	37	34	35	28	25	33	30
DCBRE	9	10	9	8	8	7	7
DRNL	–	–	–	–		–	–
OTHERS	45	40	44	47	41	39	40

TABLE 5 — Professional Staff Turnovers, 1962-1967, by Degrees

I DOCTORATES

	1962	1963	1964	1965	1966	1967
DRAE	Nil	16.6	20.0	Nil	Nil	25.0
CARDE	4.3	35.0	10.5	9.1	Nil	10.8
DRES	7.1	Nil	Nil	33.3	5.9	6.6
DREA	14.3	Nil	7.7	30.0	10.0	Nil
DREP	25.0	12.5	Nil	12.5	16.0	40.0
DRET	9.1	22.7	9.5	9.1	16.0	26.0
DRTE	20.7	11.1	3.4	12.9	3.3	3.0
DCBRE	3.6	6.9	Nil	3.2	Nil	12.1
OTHERS	Nil	3.4	7.1	8.0	3.3	5.0

II MASTERS

	1962	1963	1964	1965	1966	1967
DRAE	Nil	5.2	Nil	14.5	Nil	4.8
CARDE	13.3	6.6	Nil	6.4	Nil	9.1
DRES	14.3	Nil	11.1	Nil	13.3	6.6
DREA	23.0	Nil	11.1	5.5	Nil	4.5
DREP	Nil	Nil	7.7	Nil	9.1	8.3
DRET	16.6	Nil	Nil	6.6	75.0	Nil
DRTE	5.0	4.5	4.3	3.1	2.8	Nil
DCBRE	9.1	Nil	10.0	Nil	14.3	7.7
OTHERS	6.6	Nil	13.3	7.7	8.7	Nil

III BACHELORS

	1962	1963	1964	1965	1966	1967
DRAE	3.4	3.4	3.2	9.2	6.6	7.0
CARDE	11.3	10.2	4.3	7.1	7.7	3.8
DRES	Nil	10.0	Nil	11.1	11.0	12.5
DREA	5.9	6.2	Nil	Nil	4.1	8.7
DREP	Nil	Nil	Nil	Nil	Nil	8.3
DRET	Nil	Nil	Nil	Nil	75.0	Nil
DRTE	5.4	8.8	11.4	14.3	16.0	6.0
DCBRE	Nil	Nil	22.2	25.0	Nil	43.0
OTHERS	4.4	5.0	4.5	4.3	Nil	7.0

TABLE 6 — The Number of Personnel on 1 July, 1968 in Each Degree Category on Education Leave

		Bachelor	Master
DRAE			
	Directorate of Air Operational Research		1
	Directorate of Maritime Operational Research	1	
	Directorate of Mathematics & Statistics	1	
CARDE			
	Electronics Division	2	1
	Aerophysics Division	3	1
DRES			
	Research Division		2
DREA			
	Engineering Physics Division	1	2
	Physics Division	1	
DREP			
	Marine Physics I Division		1
	Marine Physics II Division		1
	Materials Engineering Division		. 1
DRET			
	Physiology Division		1
DRTE			
	Radio Physics Laboratory		2
	Chemical Laboratory		2
DCBRE			
	Biological & Chemical Division		2
	TOTAL	9	17

TABLE 7 — The Number of University Students Given Summer Employment in Scientific Activities, 1962-1968

Year	DREA	CARDE	DRES	DREA	DREP	DRET	DRTE	DCBRE	DRNL	OTHERS	TOTAL
1962	17	41	11	7	10	11	24	8	3	0	132
1963	13	28	7	7	8	11	33	15	2	7	131
1964	14	24	9	9	10	9	29	14	0	3	121
1965	13	30	7	10	9	9	25	13	–	2	118
1966	14	27	8	11	9	10	27	14	–	3	123
1967	15	25	8	11	7	8	22	17	–	2	115
1968	13	23	10	9	8	9	21	11	–	2	106

ANNEX VI — EXPENDITURES ASSOCIATED WITH SCIENTIFIC ACTIVITIES

1. The following five tables show the expenditure of DRB funds on scientific activities according to the categories given in the "Guide for Submission of Briefs and Participation in Hearings". The definitions of the categories and their sub-divisions given in Appendix B of the Guide were used in conjunction with the definitions used by the Dominion Bureau of Statistics in the Survey Form "Federal Government Expenditures on Scientific Activities" issued in 1967. It should be noted that since DRB is a research organization *all* its funds are expended on scientific activities.

2. The amounts in Tables 1, 2 and 3 were derived by judicious treatment of available data by scientific staff familiar with the nature and extent of the Board's scientific activities for the period concerned. The amounts are therefore informed estimates rather than exact amounts. The reason is that up to 1966/67 resources were allocated and expenditures accounted for by the traditional governmental method based on objects of expenditures and organizational units. Hence there are no records for these years on the expenditures associated with the functions, scientific disciplines, etc., as defined in the guide-lines. In 1967/68 the Board began to categorize expenditures by projects but even these do not yield the required data directly because the great majority of projects are interdisciplinary.

3. The amounts in Tables 4 and 5 were taken directly from records.

4. Table 4 shows operating and capital expenditures for DRB headquarters and the research establishments for the period 1962-63 to 1967-68 and the estimates for 1968-69.

TABLE 1 — Expenditures by Function (1) (in thousands of dollars)

	62-63	63-64	64-65	65-66	66-67	67-68	68-69
Operational							
Intramural	26,800	27,300	27,300	29,900	31,300	34,600	36,200
Scientific Information	400	400	500	500	500	600	600
Industry Support	1,200	3,400	6,400	8,300	9,000	8,000	4,500
University Support	1,900	1,900	1,900	2,100	2,500	2,800	2,900
TOTAL	30,300	33,000	36,100	40,800	43,300	46,000	44,200
Capital							
Research Ship						3,700	6,100
Major Construction	600	600	700	800	900	700	500
TOTAL	600	600	700	800	900	4,400	6,600
GRAND TOTAL	30,900	33,600	36,800	41,600	44,200	50,400	50,800

NOTE: 1. Estimated expenditures for fiscal year 1968-69.

TABLE 2 — Expenditures By Scientific Disciplines (1) (2) (in thousands of dollars)

	62-63	63-64	64-65	65-66	66-67	67-68	68-69
Engineering and Technology	18,200	20,600	23,700	27,200	28,900	29,900	26,600
(RSP) (3)		(800)	(2,600)	(3,000)	(4,300)	(3,500)	
Natural Sciences							
Atmospheric Sciences	1,100	1,100	1,100	1,300	1,300	1,500	1,600
Biology	600	700	700	700	700	800	900
Chemistry	900	900	900	1,000	1,100	1,400	1,500
Medicine	2,100	2,100	2,100	2,300	2,400	2,600	2,900
Oceanography	1,100	1,100	1,100	1,200	1,300	1,400	1,500
Physics	5,200	5,400	5,400	5,900	6,200	6,900	7,600
Solid Earth Sciences	300	300	300	300	400	400	500
TOTAL	11,300	11,600	11,600	12,700	13,400	15,000	16,500
Social Sciences							
Psychology	800	800	800	900	1,000	1,100	1,100
GRAND TOTAL	30,300	33,000	36,100	40,800	43,300	46,000	44,200

NOTES:
1. Does not include major construction or research ship construction (Table 1) because they cannot be identified with a particular discipline.
2. Estimated expenditures for fiscal year 1968-69.
3. Responsibility of Research Satellite Program (RSP) transferred to proposed Department of Communications in 1968-69.

TABLE 3 — Expenditures by Area of Application (1) (2) (in thousands of dollars)

	62-63	63-64	64-65	65-66	66-67	67-68	68-69
Space Travel and Communications		800	2,600	3,000	4,300	3,500	
War and Defence	30,900	32,800	34,200	38,600	39,900	46,900	50,800
Telecommunications	(5,100)	(5,000)	(5,200)	(5,300)	(5,700)	(6,600)	(4,900)
TOTAL	30,900	33,600	36,800	41,600	44,200	50,400	50,800

NOTES: 1. The amounts shown in Space Travel and Communications are the costs of the Research Satellite Program, which has been transferred to the proposed Department of Communications in 1968-69 fiscal year. The rest of DRB's budget is related to War and Defence. However a portion of DRB's budget spent on research related to military communications is relevant (to a significant degree) to general telecommunications, also. This part is identified separately as Telecommunications but it is also part of War and Defence.

2. Estimated expenditures for fiscal year 1968-69.

TABLE 4 — Operating and Capital Expenditures by Unit

Expenditures ($000)		700 HQ	701 CARDE	702 DRES	704 DRKL(a)	705 GIES(b)	707 DREA	708 DREP	709 DRNL(c)	710 DRAE(d)	711 DRET	713 DRTE	714 DCBRE	TOTAL
1962-63	Operating	4,678	6,539	2,828	342	5	1,546	775	215		994	3,822	1,050	22,794
	Capital	780	1,563	305	20		354	370	42		45	1,295	173	4,947
	TOTAL	5,458	8,102	3,133	362	5	1,900	1,145	257		1,039	5,117	1,223	27,741
1963-64	Operating	5,229	6,270	2,805		9	1,798	797	223		949	3,821	1,321	23,222
	Capital	802	1,499	347			394	254	39		68	1,149	534	5,086
	TOTAL	6,031	7,769	3,152		9	2,192	1,051	262		1,017	4,970	1,855	28,308
1964-65	Operating	5,358	6,241	2,852			1,714	863	214		969	3,883	1,326	23,420
	Capital	1,138	1,467	367			313	216	8		125	1,295	156	5,085
	TOTAL	6,496	7,708	3,219			2,027	1,079	222		1,094	5,178	1,482	28,505
1965-66	Operating	5,988	6,850	3,286			1,841	1,031	55		1,073	4,234	1,459	25,817
	Capital	1,128	1,613	465			606	222			133	1,035	274	5,476
	TOTAL	7,116	8,463	3,751			2,447	1,253	55		1,206	5,269	1,733	31,293
1966-67	Operating	6,112	7,553	3,585			2,069	1,052			1,184	4,875	1,618	28,048
	Capital	18	1,753	557			513	488			170	822	347	4,668
	TOTAL	6,130	9,306	4,142			2,582	1,540			1,354	5,697	1,965	32,716
1967-68	Operating	7,311	7,926	3,714			2,172	1,172			1,415	5,369	1,710	30,789
	Capital	3,749(e)	1,740	475			485	373			489	1,201	246	8,758
	TOTAL	11,060	9,666	4,189			2,657	1,545			1,904	6,570	1,956	39,547

TABLE 4 — Operating and Capital Expenditures by Unit (Cont'd)

Expenditures ($000)		700 HQ	701 CARDE	702 DRES	704 DRKL(a)	705 GIES(b)	707 DREA	708 DREP	709 DRNL(c)	710 DRAE(d)	711 DRET	713 DRTE	714 DCBRE	TOTAL
Estimates														
1968-69	Operating	8,252	8,230	3,708			2,489	1,400		1,119	1,419	5,814	1,824	34,255
	Capital	6,264(e)	1,549	618			713	328			418	1,078	223	11,191
	TOTAL	14,516	9,779	4,326			3,202	1,728		1,119	1,837	6,892	2,047	45,446
	GRAND TOTAL	56,807	60,793	25,912	362	14	17,007	9,341	796	1,119	9,451	39,693	12,261	233,556

NOTES: (a) Defence Research Kingston Laboratory was closed in 1964 and the program and staff combined with DCBRE, Ottawa.

(b) Grosse Ile Experimental Station was transferred to the Department of Agriculture in 1964.

(c) Defence Research Northern Laboratory was transferred to the National Research Council in 1965.

(d) Defence Research Analysis Establishment was first provided with separate funding in 1968-69.

(e) Includes funds for research vessel under construction.

TABLE 5 — Funds Expended to Further Professional University Education of Staff

Year	Scholarships to Existing Staff	Financial Assistance to New Employees*	Total
1962-63	$ 14,694	$ 6,718	$ 21,412
1963-64	6,921	11,782	18,703
1964-65	35,471	5,155	40,626
1965-66	83,430	5,761	89,191
1966-67	124,595	6,340	130,935
1967-68	144,881	9,000	153,881
1968-69 (to date)	46,522	3,750	50,272

* Expenditures for graduate students who have not yet done work for the Board but who are taken on strength while still doing university work and, subsequent to graduation, are placed in DRB establishments.

ANNEX VII RESEARCH POLICIES

PART I INTRAMURAL RESEARCH ACTIVITIES

PROGRAM AND PROJECT SELECTION

1. The process of selecting, initiating and monitoring intramural programs and projects is characterized by extensive consultation between the Defence Research Board, the Canadian Forces and the research and development agencies of our allies, particularly the United States and Great Britain. Most of this consultation takes place informally on a continuing basis by means of visits, meetings and conferences. The process establishes the areas of defence requiring both short-term and long-term research attention and hence the requirements for both applied and basic research. The selection of particular programs and projects within these areas is based on defence equipment and knowledge requirements, resources available including Canadian expertise and facilities, and the value to both Canada and her Allies. Duplication of work being done in other countries is diligently avoided. The programs finally selected are those most closely related to Canadian defence problems and most valuable in the context of exchanging defence scientific information with our allies because of their relevance to both Canadian and Allies' programs.

2. Policy formulation, program planning and reviewing are the responsibility of the central headquarters, but the Board's policy of delegating implementation of centrally determined policy and program decisions to the performing units (i.e. the research establishment) means that the initiation and monitoring of projects at the scientific and technical levels is the establishments' responsibility. It is emphasized that HQ approval must be obtained before initiation and that on-going programs are subjected to periodic reviews by a senior committee known as the Program Review Group. This is a formal process which formally establishes whether or not programs are justified in relation to requirements, available resources and work in other agencies, departments and countries. The scientific and technical quality of the work is also critically examined and only those of high quality receive support. The Chief of Plans and his staff have the responsibility of analyzing and evaluating

existing, proposed and required programs in the context of DRB's overall responsibilities and resources and of making recommendations to the Program Review Group.

ESTABLISHMENT OF PRIORITIES

3. For the past five years relative priorities of projects and programs were established, in part, by use of a Merit Rating system. Merit ratings were derived to give a numerical value for the intrinsic importance of projects. The process involved qualitative and subjective judgments by the specialists in the performing organization in relation to defence requirements, foreign programs, anticipated degree of success and the estimated value of the results. The numerical value so obtained was used as an aid to decision-making and not as a determinant by itself.

4. The complete range of programs and projects encompasses work in many fields of science, engineering and technology and most fields have activities in many areas of the research and development spectrum from objective basic research to preliminary development. Priorities are expressed and implemented in different terms in different areas. Thus, in common with most government and industrial research organizations, objective basic research priorities are expressed in terms of the manpower and financial resources that are alloted to selected areas. In applied research and preliminary development they are expressed in similar terms but with the addition of target dates or milestones designed to complete the tasks at a predetermined time. In the preliminary development phases of projects critical path networks and similar techniques are used wherever appropriate — for example, they have been used in the development of the meteorological rocket at CARDE and the satellite programs at DRTE.

CONTRACTUAL PROJECTS IN SUPPORT OF INTRAMURAL PROGRAMS

5. The Board's policy has always been to do as much research as possible by contract with industry, universities and other agencies. Its aims have been to avoid building up within the Board any facilities or teams of experts which would duplicate those existing elsewhere in Canada and to bring to bear on defence science problems any and all Canadian expertise and capabilities wherever they may be found. The Board's policy regarding the funding of extramural research programs will be found in Part II of this annex.

6. The following table of expenditures for research in support of intramural programs gives the dollar value of the contracts in industry, universities and other Government agencies.

	Industry	Universities	Gov't Agencies
1963-64	1,200,000	400,000	160,000
1964-65	3,371,000	447,000	168,000
1965-66	3,994,000	368,000	180,000
1966-67	4,993,000	417,000	180,000
1967-68	4,238,000	642,000	198,000

7. The kind of work and distribution of research projects between the various sectors is illustrated below in the list of research contracts costing $15,000 or more placed in the current fiscal year (1968/69). The list does not include contracts placed in previous years which are continuing in this fiscal year nor grants to universities and industry for research purposes.

Title of Contract	Amount $	Agency, Firm or University
1. Study of Terrain Evaluation for Mobility	22,200	McGill University
2. Study in the Physical Properties of Ice	24,560	McGill University
3. Study of Rate Effects On Development of Soil Strength Related to Dynamic Similitude of Vehicles	23,260	McGill University
4. Study of "Detection of Signals in Noise"	24,993	Queen's University
5. Studies Related to Microwave Propagation	15,800	McGill University
6. Meteorological Studies of the Hazen Lake Tanquary Fiord Areas	17,500	McGill University
7. Structures and Properties of Uranium Based Alloys	24,900	University of British Columbia
8. Theoretical and Experimental Studies on Microwave Scattering Phenomena from Hypersonic Turbulent Wakes	24,810	Laval University
9. Study of Electrostatic Probe Techniques	45,000	RCA Victor Company Limited, Montreal, Quebec.
10. Studies on Difunctional and Trifunctional Hydroxyl-terminated Polyether	20,000	Laval University

Title of Contract	Amount $	Agency, Firm or University
11. Research Program on Polymer Materials	25,000	Polymer Corp., Sarnia
12. Research in Rocket Motor Stress Analysis	24,000	Nova Scotia Technical College
13. Studies in Radiation Effects with relation to Stratosphere and Mesosphere	15,402	University of Saskatchewan
14. Research on the Radiation Effect in the Ultraviolet and Visible Regions of the Spectrum from Nuclear Explosions	15,000	York University
15. Investigation of Ceramic Materials in multi-oxide systems	38,062	Duplate Canada Limited
16. Fundamental Studies of the Structure and Physical and Mechanical Properties of Thin Electrodeposited Metal Foil	18,000	Nova Scotia Technical College
17. Contractual Support of Research Satellite Program		
(a) Operation and Maintenance of the DRTE Telemetry Station	85,000	Computing Devices of Canada, Bells Corners, Ontario
(b) Operation and Maintenance of the DRTE Data Processing Center	120,000	Philco-Ford of Canada
(c) Operation and Maintenance of the Satellite Control Office	40,000	Computing Devices of Canada
(d) Maintenance of DRB Equipment at Resolute Bay	15,500	Computing Devices of Canada
(e) Design, Fabrication, and Launch Operations of ISIS "B"	2,800,000	RCA Victor Company Limited, Montreal, Quebec.

8. The number of smaller contracts placed to date is 14. Six are in the range $2-5,000, five in the range $6-10,000 and three in the range $10-14,000.

RESOURCE REALLOCATION ARISING FROM PROGRAM CHANGES

9. Changes in the technological environment and in defence requirements have made it necessary to shift research resources from one program to another. In a few cases, programs have been terminated. The main difficulties that arise are associated with personnel and facilities.

10. In most cases it is neither desirable to suddenly terminate the employment of staff nor to lose the scientific and technical knowledge and expertise that has been developed. Considerable effort is made to reorient programs so that the staff's abilities may be applied to new problems or duties.

11. Although many shifts of programs have been accomplished in such a way as to re-utilize the staff in new or changed programs, the complete termination of a program has sometimes necessitated a loss of at least some of the staff. For example, in 1961 it was decided to close out a program of food research and technology which had been conducted successfully for several years. Of seven professionals, three resigned, two were successfully transferred within the establishment and two elsewhere within DRB. In another instance, it was decided to terminate a chemistry program in two phases; following the first phase the three professionals involved decided almost immediately to leave DRB. Of the three scientists employed in the work which was terminated later, one was successfully reallocated within the establishment, one elsewhere within DRB, and the third in another federal government research agency.

12. In short, personnel problems associated with program changes are resolved by the processes of attrition, re-orientation, and transfer to new posts and duties, such as scientific administration and liaison.

13. Facilities and equipment pose serious problems only when they are unique to the program being terminated. Equipment is either transferred to another establishment which can use it or declared surplus and transferred to Crown Assets Corporation for disposal. When buildings and major installations are involved their possible usefulness to other government departments is investigated and, if appropriate, a transfer is arranged. Otherwise they are transferred to Crown Assets Corporation. In some cases the Board may offer useful advice to the Corporation concerning the disposition which would be to the best public advantage.

TRANSFER OF RESEARCH RESULTS TO OUTSIDE AGENCIES

14. Intramural and contracted extramural research results are transferred to industry, other government agencies, and universities having potential need

of them in a variety of ways. First and foremost is the publication of results in the scientific literature or the establishments' own series of reports and technical memoranda. The latter are catalogued in the document holdings of the Defence Scientific Information Service. These are automatically announced to DSIS customers in industry, appropriate government agencies and others who request information from DSIS, where not precluded by the security restrictions which must be applied to some of these documents. Results are also transferred by means of patent action. (Statistics on the number of such reports will be found in Annex VIII).

15. Transfer also takes place from individual to individual by presentation of papers at meetings of professional societies and by visits of DRB personnel to universities, other agencies and industries. Similar visits are made by extramural scientists and engineers to DRB establishments. Transfer at the individual visit level is particularly effective in connection with the Industrial Research Grant program.

16. Research results are also communicated in informal seminars or meetings originated and convened by the establishments in selected fields and areas of science and engineering to which extramural personnel are invited.

PART II EXTRAMURAL RESEARCH ACTIVITIES

GENERAL

17. Under the provisions of the National Defence Act, the Defence Research Board is responsible for research in Canada in fields of primarily defence interest. One of the ways the Board carries out this responsibility is to foster and support fundamental research in Canadian universities and applied research in Canadian industry through a system of grants.

18. DRB has no units whose sole activity is the funding of extramural scientific activities but it does have a separate Parliamentary Vote for the stimulation and support of defence research in Canadian universities and industry. This vote is administered by the Board's Headquarters as two separate programs — one for university grants, another for industrial research grants. However, as will be explained later in more detail, the scientific monitoring

of individual grants is done by scientists and engineers in the various establishments. Although these programs have many similarities, the differences are significant and so each is described separately and in detail in Appendices.

19. University Grants Program. The awarding of grants to members of university staffs has three objectives. The first is to acquire new scientific knowledge that may prove applicable to the solution of technical defence problems; the second is to develop and support in the scientific community as a whole an interest in defence science that will have a potential value in the long-term maintenance of a defence research capability; the third is to assist in staffing the various establishments of the Board with promising young scientists. The main criteria used in judging grant applications are the scientific quality of the proposed work and its relevance to defence interests; it need not be related to the intramural program of the Board.

20. Defence Industrial Research Program. Grants are awarded to promote and strengthen the research capability of Canadian industry in defence technologies Assistance is available to enable firms to establish new research programs or to expand existing research activities. The ultimate goal is to improve both the quality and quantity of applied research in Canadian defence industry so as to enhance its ability to meet the needs of the Canadian Armed Forces competitively and to participate in the development and supplying of equipment to our allies.

21. Projects submitted to DRB for appraisal are initiated by Canadian companies and are not necessarily related to the DRB intramural program.

22. The Advisory Committee on Defence Industrial Research which examines and makes recommendations regarding company proposals, is an interdepartmental committee composed of representatives from the Defence Research Board, National Research Council, Department of Industry and Department of Energy, Mines and Resources. Once the research stage is completed, it is possible to advance a program into the development stage through various assistance programs of the Department of Industry. Proposals having minimal defence interest can be referred to the National Research Council for consideration for support under

their Industrial Research Assistance Program. By this means, duplication of support of research programs in similar fields of endeavour by separate Federal agencies is avoided.

APPENDIX A - ANNEX VII

UNIVERSITY GRANTS PROGRAM

SELECTION OF PROJECTS

1. Annually in August, information is sent out to all Universities in Canada concerning the DRB Extramural Grants program. The information consists of a general announcement for posting on bulletin boards and circulation to staff members, a letter to all Academic Deans, and brochures delineating the major areas of the Board's scientific interests. Submission of applications is requested by 1 November.

2. As applications are received from University staff in late October, each one is allocated to its appropriate field, and automatically becomes potentially a "project" therein.

3. Since the Board is now receiving a volume of research grant applications which exceeds by a factor of 2 the funds available, rather rigid criteria of selection must be employed in deciding which projects qualify for support. The first basis for evaluation is of course the scientific quality of the submission; secondly, since the Board's activities must be mission-oriented, the degree of relevance which an application has to problems of defence science must be established.

4. To evaluate scientific quality, we have some 25 Advisory Committees and Panels comprised of experts in their specific fields and drawn from the Universities, other government departments, and industry. Each Committee reviews all applications assigned to it, and grades them on scientific quality. In arriving at the grade, committees examine the research accomplishments of the applicant, his publication record, the completeness and relevance of his method of approach, and his experimental plan. In the case of a relatively inexperienced applicant, i.e. a recent graduate, such factors as his academic record, the reputation of the department, faculty, and University where he received advanced training are also factors in the selection process.

5. Since it is the policy of the Board (as enunciated in the National Defence Act) to support only that research which is of interest to defence, all applications are scrutinized also on that basis. In this operation a 5 point scale is used to *categorize* projects, rather than to rate them competitively. Category I identifies projects of current applicability to present Establishment programs; Category II identifies projects on which Establishment scientists would be working if time and manpower permitted; Category III is used to identify projects which, while not of specific interest to Canadian defence problems, are nevertheless of broad defence significance; Category IV identifies projects not included in the first three, but of some importance in that training would be accorded to students (potential Board employees) in areas wherein defence applicability might be expected to increase. Category V identifies projects in which no defence interest can be discerned.

6. It should be noted that the foregoing are *categories* not grades. Thus, a Category II or Category III project might be of greater significance than a Category I project and be preferred for support because Categories I, II, and III are regarded as being of approximately equal significance.

7. The University Grants Review Committee meets again after the reports of the Advisory Panels have been submitted, reviews their findings together with any other expert opinions obtained and makes recommendations which are submitted, along with the Advisory Committee reports, to the Defence Research Board for review and submission to the Minister of National Defence.

EVALUATION OF RESULTS

8. An annual progress report is submitted in October by each grant recipient and is evaluated by Establishment scientists and by the appropriate Advisory Committee. That study is carried out in conjunction with examination of the application for support during the ensuing fiscal year.

PRIORITY IMPLEMENTATION

9. Speaking generally, priorities are implemented by controlling the proportion of available funds allocated to programs comprising the various disciplines and sub-disciplines. A small committee of the Board (the University

Grants Review Committee) consisting of the Chairman of the Standing Committee on Extramural Research, the Deputy Chairman (Scientific), the Chief of Plans, and the Executive Secretary, University Grants, meets annually in December to determine appropriate apportionment of the available funds to some 15 fields which the Board is either supporting or proposes to support in the fiscal year under consideration. The Committee has available to it Establishment opinions and those of the Armed Services as to areas wherein support should be increased or decreased, as the case may be.

10. Insofar as individual projects are concerned, priorities are implemented during the selection process described in paragraphs 2-8.

REALLOCATION OF RESOURCES

11. If the changing technical environment requires a shift in resources and a decrease in the funds allotted to a particular field, such a decrease is effected by reducing the number of grants in that field. It is Board policy to give a year's notice of intent to holders of grants which are to be terminated. No difficulties have been encountered in the operation of this system of termination.

TRANSFER OF RESULTS

12. The transfer of results to those having need of them is accomplished in three ways. The first of these is through direct liaison between the Board's scientific staff and the grantees; the second is by submission of the annual reports referred to earlier; the third is by publication in scientific journals.

EXPENDITURE OF AVAILABLE FUNDS

13. In each of the years 1962/63 - 1966/67 100% of the funds available was actually expended.

PROPORTION OF REQUESTS ACTUALLY GRANTED

15. The percentage of the total funds requested that were in fact granted was:

1962-63 — 71%

1963-64 — 62%

1964-65 — 56%

1965-66 — 60%

1966-67 — 53%

1967-68 — 59%

16. The volume of applications has increased steadily. The improved ratios shown for 1965-66 and for 1967-68 result from the fact that in those years we were able to increase our university grants budget by $140,000 and $400,000 respectively. (Figures for 1968-69, however, demonstrate the lowest ratio on record, i.e. 42%).

APPENDIX B - ANNEX VII

DEFENCE INDUSTRIAL RESEARCH PROGRAM

GENERAL

1. This program was inaugurated in the summer of 1961 when it became apparent that in addition to the support which was already being given to industry in the development of defence equipment, there was a need to stimulate and promote the creation or extension of Canadian industry's research capability.

2. The responsibility for this program was given to the Defence Research Board. In a brief to the Treasury Board and the Department of Defence Production given in October 1961, DRB outlined its plans and described the program as being intended "to increase Canada's ability to participate in the development and supply of defence equipment to meet North American and NATO requirements. Thus, the DIR program will provide an essential complement to the existing development and production sharing programs sponsored by the Department of Defence Production".

3. With the establishment of the new program, the Defence Research Board set up a Directorate of Industrial Research and arranged for appropriate scientists in its establishments to advise and assist the Director. Technical advice is also sought when required from other government agencies such as the National Research Council, Energy, Mines and Resources and the National Aeronautical Establishment. The Department of Industry cooperates with DRB in the appraisal of the financial and industrial aspects of the companies who are receiving support under the program.

4. The initiative for submitting proposals rests with industry. Grants are available only to companies or groups of companies incorporated in Canada and such grants are given only for research to be performed in Canada. Financial assistance is provided in the form of non-refundable grants for specific research projects of broad defence interest. Normally the Crown and the company share equally the total cost of the research. The results of the research must be exploited in Canada, unless exceptional circumstances warrant

otherwise. Research data, patents and equipment remain the property of the company. However, licensing to a foreign user requires permission from DRB and the Crown has royalty-free use.

5. A special agreement exists between DRB and the United States Air Force (USAF) whereby the latter agency may share in the provision of support of defence research projects in Canadian industry. Since Canadian financial input comes from the DIR fund, such projects must meet the aim of the DIR program; they must also be of sufficient interest to the USAF to warrant their support. In cases where support is given in this manner, the company normally makes no financial contribution, though a three-way split is possible. Six joint projects currently are being carried out with USAF support.

SELECTION OF PROJECTS

6. In the early stages of the program the normal DRB-DDP contracting procedures were followed, but this system imposed delays and has since been replaced by an arrangement whereby the companies are given non-refundable grants.

7. The initial company proposal is screened by DRB specialists who discuss it with the company and, if necessary, with specialists in other government departments. If the initial appraisal is favourable, the company is invited to submit a formal proposal for consideration by the Advisory Committee on Defence Industrial Research which has representation from DRB, DOI, NRC, EM&R and Treasury Board. The submission is accompanied by a brief from DOI giving its appraisal of the company.

8. If the Committee recommends that a grant be given and the recommendation is accepted by CDRB and the Minister of National Defence, a proposal is forwarded to Treasury Board. On approval of TB, DRB and the company sign a grant agreement.

9. In deciding whether or not to recommend a grant, the Advisory Committee takes account of the following:

(i) The company's previous research record — if the Company has received grants previously, their record of performance is well known to the DRB project officer and is taken into account in the assessment of the proposal. If the Company is new to the program, the scientific qualifications and experience of the individuals conducting the research are assessed as well as the research facilities provided by the Company and the Company's attitude toward research.

(ii) The nature of the proposed project — it must be relevant to an important defence requirement, preferably one offering good prospects for the eventual sale of equipment to our allies. It must also be scientifically sound and have a good chance for a successful outcome. The DRB project officer frequently seeks expert advice from other government agencies to assist him in his appraisal.

PRIORITIES

10. Until FY 1967/68, the funds available to this program were adequate to support all deserving proposals received from industry. Since April, 1967, however, the Crown funds allocated to the program have been limited to $4.5M per fiscal year. This has required that proposals be treated on a more competitive basis, with priority being given to those proposals which are directly relevant to defence and show the best prospects for exploitation in the defence export market.

MONITORING AND ASSESSMENT

11. DRB and DOI each appoint a project officer whose duty it is to monitor progress and to visit the Company, as required. Each project is reviewed once a year by the project officer and a recommendation is submitted to the Advisory Committee on Defence Industrial Research for or against continuation of the grant.

12. Projects normally run for 2 to 3 years. If the initial work shows that further research is required, the company may request an extension; such a proposed extension is given the same appraisal as a new submission. Many companies have several DIR projects running simultaneously.

13. To obtain some measure of the effectiveness of the program, a simple questionnaire is sent each year to all holders of currently-active grants. It asks for the number of scientists and assistants being supported, the increase in research facilities, the number of scientific publications issued, the number of patents obtained and so on. It also seeks to obtain some measure of the increase in sales directly or indirectly attributable to the research program; however, since the relation between a research project and sales is often difficult to trace in measurable terms, such information must be treated with a certain amount of reserve.

PRIORITIES IN ALLOCATION OF RESOURCES

14. Since the initiative for submitting proposals lies with individual companies, little attempt has been made to allocate funds to specific technological areas. In view of budgetery restrictions, however, consideration is being given to setting priorities. Possible factors would be the importance of a particular area (e.g. high-temperature materials for jet engines) in the current spectrum of defence problems, and possible relevance to DRB's own research program.

USE OF NETWORK METHODS

15. Individual companies such as Canadair Limited use network methods to plan and monitor their R&D programs. Such methods are of limited value, however, in the research phase, where costs are relatively low and the timing of progress is difficult to predict.

TRANSFER OF RESOURCES

16. As mentioned above, all projects are critically assessed at the end of each fiscal year for continuation in the following year. Possible reasons for termination could be negative research results, failure on the part of the company to pursue the research objectives, loss of key personnel and so on. Normally, termination would be discussed with the grantee in an effort to reach mutual agreement on the course of action to follow.

TRANSFER OF RESEARCH RESULTS

17. The Company performing the research is usually also in the best position to exploit it. Both the DOI and DRB project officers are constantly alert to the possibility of exploitation and frequently help the grantee with advice on follow-on programs. This can include suggestions concerning possible collaboration with other companies who can take advantage of the information arising out of the research program.

EXPENDITURE OF AVAILABLE FUNDS

18.	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68
Available	$1,375,000	$5,300,000	$4,150,000	$5,788,000	$5,800,000	$4,500,000
Expended	$1,197,814	$2,582,726	$3,839,266	$5,309,239	$4,702,310	$4.499,847
Percentage	82%	49%	93%	92%	81%	100%

FUNDS REQUESTED

19. It is difficult to give a meaningful figure for the amount of funds requested. Many proposals are screened out during preliminary, informal discussions, so that the amount requested is never recorded. The figures below cover only formal proposals which were submitted to the Advisory Committee for their assessment. It should also be noted that the amount granted in any fiscal year may be greater than the amount actually spent since the grantees are sometimes unable to spend the funds at the rate forecast.

	1962/63	1963/64	1964/65	1965/66	1966/67
Requested	$1,922,067	$3,548,562	$5,037,837	$7,572,162	$6,544,604
Granted	$1,764,622	$3,494,562	$4,830,837	$6,911,076	$6,179,604
Percentage	92%	99%	96%	91%	94%

APPENDIX C — ANNEX VII

PROFESSORSHIPS OF MILITARY AND STRATEGIC STUDIES

1. Approximately one year ago, the Department of National Defence (DND) decided to terminate its officer-training programs in the Universities of Canada, i.e. the UNTD, COTC, and ROTP.

2. The Canadian Armed Forces were anxious, however, to maintain a connection with the Universities of Canada, and examined a number of possibilities which might contribute to that objective. The most effective and attractive possibility was through the establishment of a number of professorships of military and strategic studies in selected Universities.

3. The basic aim of the new program was to provide focal points of academic and applied military knowledge in order that undergraduate and graduate students might be provided with facilities to study problems of international and national security and allied matters in a purely Canadian context.

4. The proposal of DND was discussed by Cabinet and approved in principle in September 1967. That approval covered the establishment of 6 professorships, to be selected by an independent Committee, and awarded in open competition among the Universities; the awarding of a small number of fellowships and scholarships to promising students; the provision of funds to support research programs put forward by the professors; the allocation of $250,000 annually to these purposes. The Cabinet also enjoined that factors of culture and geography be considered in the selection process, and that all aspects of the program be unclassified.

5. In pursuance of this Cabinet decision, Mr. A.D.P. Heeny, Chairman of the International Joint Commission, was invited to act as Chairman of the Selection Committee. Because of its long experience in handling grants to Canadian Universities, the Defence Research Board was instructed to carry out the administrative duties involved in the operation of the program.

6. In order that all Universities might be made aware of DND's willingness to support such professorships, the Department requested that the Association of Universities and Colleges of Canada (AUCC) distribute announcements to its member institutions. To this AUCC agreed, and the information was disseminated to all Universities in February 1968.

7. In response to the announcement, 14 Universities submitted proposals applying for the award of 1 of the professorships. Of these, the Selection Committee selected 5, i.e. Acadia, Laval, Carleton, Queen's and Victoria as recipients. One award is being held in abeyance in order that funds will be available should the services of a distinguished visitor become available.

8. Although the program provides for 4 scholarships, each having an annual value of $5,000, none has as yet been awarded. It was the opinion of the Selection Committee that the professorships should be established first, and that the time necessary to make known to potential applicants the existence of fellowships and scholarships precluded the possibility of awards prior to the 1969-70 academic year. Because of its wide experience in handling programs relating to scholarships, AUCC has undertaken to promulgate information concerning these, to use its customary screening procedures, and to provide to the Selection Committee all information necessary for precise adjudication of applications.

9. Since the professorship program became effective only in September 1968, it is impossible to assess the prospects for its success. It is correct, however, to say that the Universities of Canada have demonstrated enthusiasm in applying for the awards, and appear determined to make courses on military and strategic studies an effective element of their curricula.

INTRODUCTION

1. The measurement or assessment of the effectiveness or productivity of scientific activities is a difficult problem that has not been solved by any individual or organization that has attempted the task - and there have been many. Even the much simpler problem of judging the productivity of individual researchers is surrounded by controversy. For individual productivity the most used criteria are numbers of patents, books and articles in the scientific journals - the method that has given rise to the slogan "Publish or perish". This can be done quantitatively and accurately it is true, but the criteria fail to distinguish between high quality, pedestrian and useless work.

2. If it is difficult to judge the quality of research output, it is even more difficult to judge its significance. The significance of research results has several facets - to science, to technology, to the economy, etc., and none can be measured. Furthermore their significance only becomes apparent after a lapse of time. Thus there are no true measures of scientific productivity only indicators that are of limited value.

3. A further complication insofar as DRB is concerned is that one of its primary outputs is scientific advice to the Minister and the Forces. There is no yardstick for the value of advice; even its acceptability, or lack of it, is no criterion of its true worth.

4. With these cautionary remarks concerning the weaknesses of certain quantitative data and the more general difficulties in mind, we present in the remainder of this Annex the data that is available and some qualitative and subjective indicators of the quantity and quality of the output of DRB's scientific activities.

PATENTS

5. *Intramural.* The policy of the Defence Research Board on patents is dictated by Minutes of the Treasury Board. In 1952, a Treasury Board Minute stated that the Department of National Defence would always file a patent

application on every invention which is the product of its own Research and Development *providing* it discloses possible use by the Crown and there is a possibility of obtaining a patent. In addition, Treasury Board Minute 468904 of August 1954, states that the Department of National Defence does not seek patent royalty income but that royalties and fees should not be paid to others on patents arising from departmental research. In other words, the policy is a protective policy rather than one of exploitation.

6. In view of the type of work involved, the Defence Research Board may file its patent applications in secrecy, where security regulations demand this approach.

7. The number of patents arising from research activities in the Defence Research Board during the period 1962 to 1967 inclusive, is 85 in Canada. Details of the breakdown of this figure are shown in Table 1. The data are not shown by year because the patent authorities do not have it in that form.

TABLE 1 - DRB PATENTS, 1962/67

Country Application Filed In	*Number of Applications Filed*	*Number of Patents Issued*	*Number of Patents Pending*	*Number of Submissions Under Consideration*
Canada	122	85	37	58
US	48	33	9	
UK	37	33	2	
Other	15	8	7	
TOTAL	222	159	55	58

8. During the same period, the number of licences granted by the Crown on patents issued to DRB has been six.

9. It is not possible to provide a figure for the value of resulting production in Canada and elsewhere because such records do not exist.

10. It should be noted that at least half of DRB intramural effort has been devoted to areas which seldom lead to patents such as biosciences, operational research, oceanography, geophysics, toxicology, etc.

11. *Industrial Research Program Patents*. Defence Industrial Research projects which were active in 1967 resulted in approximately 120 patent disclosures, of which about 20 resulted in patents being obtained. However, since projects can start or finish at any time during the year, and may last three years or more, it is very difficult to relate these figures to an annual output of patents. It is even more difficult to give meaningful figures for the value of resulting production. Patents are seldom used in isolation, particularly in the electronics industry, being normally used in conjunction with other patents from various sources. How then, does one relate any given patent to a volume of production? The effect is most often that of introducing an improvement into a pre-existing process or product. As part of an annual questionnaire, companies receiving DIR grants reported a total production figure of approximately $25,000,000 which they related directly or indirectly to DRB research support of all projects active in 1967. Much of the research information was not patented, however, and it is impossible to relate this overall figure to specific patents. It should also be added that most of this sum can be attributed to a relatively small number of very profitable projects; on the other hand, there are also examples of research results contributing to extremely successful product lines which are not reflected at all in the $25,000,000 figure. A major study would be required to obtain a more accurate assessment.

BOOKS OR JOURNAL ARTICLES

12. It is the Board's policy to encourage its scientists to publish as much of its research results as possible in the scientific journals. Table 2 shows the statistics for the period 1962-67.

TABLE 2 - BOOKS AND JOURNAL ARTICLES

	1962	1963	1964	1965	1966	1967	Total
Intramural	146	165	131	129	135	113	819
Extramural	112	194	217	193	72	85	873
TOTAL	258	359	348	322	207	198	1692

REPORTS

13. Each DRB establishment has its own internal series of reports and technical notes. Reports in these series are comparable to journal articles in scientific or technological quality but are published in this form because the

subject matter is either classified or related to specific applications and hence not appropriate for scientific or technical journals. Table 3 shows the statistics for such reports. It does not include technical notes.

TABLE 3 - REPORTS

	1962	1963	1964	1965	1966	1967	Total
Intramural	154	140	120	120	115	121	770
Extramural*	1	19	28	18	4	1	71
TOTAL	155	159	148	138	119	122	841

*Research Contract Reports

TRANSFER OF INFORMATION

14. The transfer of information arising from intramural programs is described in Annex VII, Appendix B, paragraph 17, and from the university grants program in Annex VII, Appendix A, paragraph 12. In the case of the defence industrial research program companies in receipt of DIR grants receive much valuable assistance from visits to DRB laboratories and by means of discussions with individual scientists. The results of company research programs are company property and cannot therefore be disclosed by DRB to other non-governmental agencies.

15. The transfer of scientific and technological information obtained from other countries requires special arrangements because of the volume and complexity of the information. These arrangements are described in the following five paragraphs.

16. Scientific and technical information in document form for defence users is obtained from friendly countries under a variety of formal agreements. A number of agencies assist in this process, but the main one concerned is the Defence Scientific Information Service (DSIS) of Defence Research Board. DSIS is responsible for acquiring, cataloguing and disseminating these documents, and for subsequent retrieval of information derived from them. (See Annex II, Appendix C for a description of DSIS' functions.)

17. Between 30,000 and 40,000 such documents are acquired annually. The majority are either security-classified or limited in availability for distribution for other reasons. The agreements under which the documents are released to Canada by the country owning them, specify that the information contained in them is to be used by Canada for defence purposes only. The agreements also specify that the documents and the information contained in them must be given the same degree of protection as that given to them by the originating country. These agreements are of course reciprocal, the other countries giving similar consideration to any Canadian information released to them.

18. DSIS' normal responsibility is to ensure that the documentary information obtained is made available to these agencies requiring it for defence purposes:

- the Canadian Forces and their contractors,
- the Department of Defence Production,
- the Defence Research Board establishments,
- DRB grantees and contractors, and
- any other departments or institutions carrying out research and development on behalf of defence.

This responsibility is met by three main methods. These are:

(a) selective circulation and distribution of documents received on a priority basis;

(b) selective dissemination of announcements of availability of documents, consistent with security requirements;

(c) catalogue searches and other aids to information retrieval, to meet specific demands.

19. These functions are still being carried out manually. Plans have been prepared, and are now being implemented, to carry out all but the intellectual parts of these processes by computer. Conversion is expected to be substantially complete by 1972, leading to an improved service for the defence scientific and technical community.

20. A portion of the material received through defence agreements has no restrictions on its subsequent use in Canada. Most of that portion is simultaneously or subsequently made available to the public in the originating

country, and could therefore be obtained directly from that country by any Canadian agency or individual. Usually, also, the same material would have been made available to the National Science Library for the benefit of the Canadian public. However, DSIS does assist many enquirers from industry and from agencies outside defence by lending unrestricted material not available elsewhere in Canada.

POST-DEPARTURE SCIENTIFIC CONTRIBUTIONS OF DRB-TRAINED INDIVIDUALS

21. Many former DRB employees hold distinguished posts in universities, industry, and other government departments and a large proportion of these launched their careers by the research training and experience they gained while with DRB. However, it is felt that it would be inappropriate to name individuals.

UNIQUE AND VALUABLE RESEARCH TEAMS, 1962-1967

22. The Board has had many valuable and unique research teams since it began in 1947. Some have ceased to exist, others were built up over a long time. The following list includes the basic and applied research teams that DRB considers to have been unique and valuable in important fields of defence science during 1962-67, and hence can be considered as national resources, created as a result of DRB's activities. No significance is to be attached to the order in which they appear.

23. *Underwater Acoustics.* Three teams of scientists at DREA working on underwater acoustics have made unique and valuable contributions during this period. One team's studies of reverberation due to the back scattering of acoustic energy from the surface, bottom, and volume of the ocean, have produced papers which are accepted as classics and have sparked much work in other countries. Of particular importance and interest has been the investigation of volume reverberation which has been shown to arise from the scattering of sound from layers of biological origin deep in the ocean. This team is the only one in Canada with a knowledge of the acoustic phenomena of these layers from Iceland to Puerto Rico and from Halifax to Gibraltar. These layers may have broad implications for biological oceanography and joint research with marine biologists of the Fisheries Research Board is planned. This team has an

international reputation and its members are in demand as consultants to US and NATO agencies.

24. The only research in Canada on the effects of design, fabrication, materials and high stresses on underwater transducer performance is carried out by a team at DREA. In addition to carrying out research into improved transducers for underwater acoustics research, investigations are made of the electrical and electro-acoustic properties of piezo-electric ceramics. In the past few years they have pioneered work on the effect of the ocean environment on the properties of these ceramics particularly on the effect of high stresses developed by high pressures deep in the ocean. The team has shown, for instance, that high stresses can, under particular conditions, considerably change the properties of the piezo-electric materials and these have implications not only for the designer of practical transducers but also to the solid state physicist.

25. *Hydrodynamics Research.* During the period 1962-67, the small team responsible originally for the research which led to the development of the hydrofoil ship HMCS *Bras D'Or* has been built into a unique hydrodynamics research team. Its strength was increased from about 5 to 14 professionals during this time. In the field of hydrofoils the team has an enviable international reputation and has provided a large support effort to the RCN and the contractor in the design stages of HMCS *Bras D'Or* and will be responsible for the scientific aspects of its performance trials. The defence interests and applicability of high-speed hydrodynamics is not confined to hydrofoil craft. High-speed hydrodynamics research is essential to the high-speed towed bodies such as variable depth sonar employed by hovercrafts, helicopters and surface vessels as well as hydrofoil craft. It is also important with respect to faired towing cables and propeller noise.

26. Interest in towed bodies has been shown by the Department of Energy Mines and Resources and the Department of Fisheries and discussions with these agencies and the Ship Section of NRC have resulted in the latter undertaking the design making use of DREA information and using BADDECK as a towing facility.

27. At DREP the underwater acoustics research resources are devoted to studies of ambient sea noise, reverberation and propagation under ice in the Arctic. A first class team with the necessary expertise in equipment design and experience in their operation under the extreme Arctic conditions has been developed. This team is a leader in the field and has produced a considerable proportion of what little information is presently available on Arctic underwater acoustics.

28. *Magnetic Anomaly Detection Research.* The chief objective of the electromagnetics team at DREP is to determine those factors in the background of the earth's magnetic field which may limit the performance of present and future submarine detection systems based on detection of anomalies in the magnetic field caused by the presence of a submarine. Data have been gathered from Northern Quebec to Antarctica, from Vancouver to Halifax, using under-the-water, buoy-suspended and aircraft-mounted equipment. The information produced by these studies is valuable not only to military equipment designers but also to geophysicists in their studies of the earth. DREP co-operates with both McGill and UBC in this area as well as with the National Aeronautical Establishment team engaged in developing improved military equipment.

29. *Electro-Optics Research.* The important technological areas of high sensitivity photo detectors and of lasers have been the objects of research for some years by a group of about five scientists at CARDE. They are abreast of the state of the art in solid state and injection lasers and are concentrating on improvements to gas lasers applications relevant to military uses for laser technology.

30. *Hypersonic Physics Research.* The Re-entry Physics Program at CARDE has developed a team of about 10 scientists with expert knowledge of the physics and aerothermodynamics of flight at high Mach numbers. Their work is an essential portion of the current research related to antiballistic missile defence technology. Their expertise is mainly valuable for military purposes, although their experience in aerothermodynamics, plasma physics, heat transfer, and physical chemistry of thermally heated gases is applicable to many problems of high energy and plasma flows, and the group is one of a very small number in Canada in this area.

31. *Upper Atmosphere Research.* A team of nine professionals at CARDE is active in studying the photochemical processes in the upper atmosphere. The team's expertise is related to military purposes such as detection of ballistic missiles, and night vision but the studies promise to assist in shedding light on climatological atmosphere.

32. *Rocket Motor Research.* DRB has at CARDE a group of about 12 professionals with outstanding competence in the various scientific disciplines needed for development of solid rocket motors. These include the chemistry and processing of solid propellants, the dynamics of propellant combustion, and the fluid dynamics of rockets. The group also has experience in the development of nozzles, casings, and igniters. A competence in structural design and aerodynamics of rockets also exists at CARDE. The propulsion group was responsible for the original development of the Black Brant series of research rockets, and is essential to the present development of a small reliable and cheap meteorological rocket. The work and knowledge of this team led to co-operative programs of rocket development with Bristol Aerospace Limited (BAL) and the CARDE technology on propellant manufacture was incorporated in the design of the BAL plant.

33. *Battery Research.* The Power Sources Division of DCBRE is the largest single group doing research and development work on batteries and fuel cells in Canada. It carries out a large proportion of all such work in Canada; for instance, virtually all the work being done on the nickel-cadmium battery system has been done at DCBRE. It has been responsible for the initiation of fuel cell research in Canadian industry and has worked very closely with the battery industry on a variety of problems. It has made many important contributions to technology in response to Forces requirements e.g. torpedo propulsion batteries, sonobuoy batteries, aircraft and search and rescue beacon batteries. It also provided considerable technical assistance concerning batteries for the Alouette satellites. Its program and expertise cover the spectrum from fundamental studies on electrochemical systems to the design and improvement of power supplies for Forces use.

34. *Nuclear, Chemical and Biological Defence.* This is an area of interest unique to defence and its scientific and technological aspects are not of much interest to universities, industry and other departments except insofar as it impinges on techniques related to pollution and public health. Furthermore, it is an area with many security restrictions. Consequently DRB has developed a number of teams at DCBRE and DRES which represent the only Canadian capabilities for research and development in this area. Briefly, they are as follows:

(a) Protection Division, DCBRE. This is the only group in Canada with the capability for research and development of protective equipment for Nuclear, Biological and Chemical Defence such as respirators and fabrics and clothing to protect against chemical and biological agents and high intensity thermal radiation. Its unique capabilities have enabled it to give valuable assistance to Atomic Energy of Canada Limited and industry in the design and development of dust masks and respirators for the protection of operators in hazardous environments.

(b) Chemistry Group, DCBRE. A group of chemists with the only Canadian expertise in the detection of chemical agents in air, water, food and soil and in the decontamination of skin, clothing and equipment.

(c) Microbiology Groups at DCBRE and DRES. These groups are unique in Canada in their knowledge of the detection, identification and behaviour of airborne bacteria.

(d) Toxicology and Pharmacology, DRES. The knowledge and expertise of the professional staff concerning the biochemistry, toxicology, prophylaxis and therapy of chemical agents of the nerve gas and other types, is unsurpassed by any other group in Canada. There are some university groups doing basic research relevant to this field and complementary to the DRES work.

(e) Hazard Evaluation. Studies of the behaviour of chemical agents in the field form a unique activity at DRES and have yielded invaluable information concerning the nature and extent of the hazards that would be faced by Canadian Forces if chemical agents were used against them.

This information has been particularly valuable in determining the standards of protection that protective clothing and equipment must provide and the training standards that must be met if troops are to make effective use of the protective equipment and procedures provided.

(f) Shock and Blast. In the past five years the team engaged in the shock and blast physics research program has developed expert knowledge in the areas of fundamental shock and blast phenomena, the interaction of shock waves with variously shaped model targets, the response of requirements and structures to dynamic loading, the formation of craters, and the seismic waves produced by free field explosions. These teams utilize the extensive shock tube and blast simulation facilities and the large free field test areas, the combination of which is unique in the western world. This has resulted in a series of extensive co-operative trials with many US and British agencies and thus provides one of the finest examples of an international defence co-operative program. The DRES work and facilities have also triggered the interest of several universities in western Canada and have, in part, led to an increase in the research at such universities in the field of shock and blast physics.

35. *Space Electronics*. The space electronics team at DRTE has been responsible for the design and construction of the space craft electronics of the Alouette satellites. The proof of its outstanding quality is the continued performance of the systems on the two Alouette satellites - after six years in orbit for Alouette I and three years for Alouette II. The performance record of these two satellites in unparalleled for such sophisticated satellites - regardless of national origin. The space electronics team is world-famous and is in the forefront of advanced electronic technology.

36. *Ionospheric Physics*. The genesis of the ionospheric physics group is found in naval communication problems of World War II and in the intervening years its work has resulted in many practical applications for use by the Canadian Forces. The group has a high scientific reputation as a result of achieving many scientific "firsts". Their analysis of ionospheric data constituted significant advances in the world's knowledge of the structure and

characteristics of the ionosphere, particularly the physics of ionospheric phenomena peculiar to the Canadian environment. For example, the relationships between disturbed communications conditions in the Canadian north and the aurora, the interactions between the upper atmosphere, the earth's magnetic field and solar radiation and activity. Studies of the lower ionosphere have led to explanations of navigational problems in the north arising from the effect of the sea ice cover on the travel of radio waves.

37. This team also developed a high frequency prediction service using a computer which forecasts the high frequencies which should be used for optimum performance in various geographic locations. These depend on the ionospheric conditions. This service is used extensively by the Canadian Forces and some civilian organizations.

38. The existence of this group in Canada has stimulated the interest of Canadian university scientists in this field of science.

39. *Modulation Techniques.* A team which is unique in Canada is concerned with investigating the many ways in which radio waves can be modulated in order to make the best use of radio circuits with respect to power input and propagation conditions. Their work is applicable to all kinds of radio communications - space and terrestrial, military and civil. So-called adaptive systems nave been developed which are self-adjusting with respect to transmission conditions. They slow down when conditions are bad; they speed up when conditions are good in response both to message load and propagation conditions. These techniques are particularly applicable to defence communications systems.

40. *Research in the High Arctic.* For many years a small team of DRB scientists have carried out research in oceanography and glaciology in the high Arctic. The leader of this team has received international recognition for his work. The team has provided base facilities and assistance to university scientists which has been most valuable in encouraging scientific research in the high Arctic.

41. *Speech and Hearing Research.* DRET has a team of scientists, unique in Canada, engaged in research on how hearing and speech perception, hearing sensitivity and acuity, in relation to voice communications, are affected by noise in the Forces environment. A program of hearing conservation for the Forces has been developed based on surveys of noise levels in virtually all Canadian Forces vehicles and aircraft. A wide variety of devices for hearing protection have been evaluated both as protective and communications-assisting equipment. Much work has been done in the field of voice communications and intelligibility in various environments ranging from aircrew and crews of armoured fighting vehicles to underwater communication between free-swimming divers.

42. *Research on Human Perception.* A unique team at DRET is engaged in the sensory aspects of signal detection and vigilance, the development of signal detection theory and its application to military vigilance situations e.g. perception of forms and shapes under difficult viewing conditions. Detrimental effects on performance related to both mental and motor skills have been measured with both civil and military tasks in mind. Human capabilities to discriminate between closely related physiological and auditory stimuli are being investigated and the team has pioneered the development of on-line, real-time computer techniques in such investigations. This work is applicable not only to the military environment but also to such matters as air traffic control and ship and motor vehicle operations.

43. *Environmental Physiology.* A team of medical, scientific and technological personnel at DRET possesses a capability, not duplicated elsewhere in Canada, for research on the physiological aspects of high pressures on personnel (e.g. diver's escape from submarines). Applied and basic studies on such problems as inert-gas, (e.g. nitrogen and helium) narcosis, decompression sickness, oxygen poisoning and related phenomena are being pursued. The team's work on oxygen poisoning has received international recognition.

44. *Human Engineering.* DRET possesses a group of scientists with outstanding capabilities in the application of the principles of human engineering in the design and modification of military hardware and in field studies of operational

performance. This work has ranged in scope from the layout and equipment of service storage areas and static installations, such as airport control towers, to field studies of navigation in very low flying fixed wing aircraft and helicopters. One of the most striking facets of this work was concerned with the direct control of engines and helm from the bridge of destroyer escort vessels. Actual trials at sea confirmed the predictions made on the basis of human engineering "know how" and a demonstration mock-up. Very recent investigations have been concerned with the operations of Department of Transport buoy-tending and ice-breaking vessels, and with the use of closed-circuit television as an aid to ship control in close quarters.

45. *Operational Research.* A group of about 60 DRB professionals are engaged in operational research and systems analysis in the Defence Research Analysis Establishment. It is the strongest team of its kind in the country and many of its alumni are in prominent positions in industry and other federal agencies. It is organized in units or teams, some in the Ottawa establishment, many attached to Canadian Forces operational units. Serving officers of the Canadian Forces constitute about 25% of the total DRAE strength.

46. The chief role of DRB has been to supply the professional civilian scientists who constitute the core of the operational research effort. Although there are transfers of personnel between DRAE and other parts of DRB, the majority of the scientists engaged in operational research are transferred from one OR team to another, and build up over the years the combination of expertise and experience that comes from working in the various aspects of one profession".

UNIQUE AND VALUABLE RESEARCH TOOLS AND FACILITIES, 1962-1967

47. The information provided in this section is confined, as requested, to unique and valuable research tools and facilities acquired during the period 1962-67. It does not mention, therefore, any equipment or facilities acquired previously. Similarly no mention is made of the multitude of modern laboratory equipments purchased from commercial sources in accordance with DRB's policy of providing its scientists with modern tools of research.

48. *Research Ships.* During this period the replacement of two of the converted World War II ocean-going minesweepers which are used as research vessels by DREP and DREA has proceeded. Early in 1965, CNAV *Endeavour,* length 235 ft. and displacement 1500 tons, specifically designed for maritime research in the fields of acoustics, magnetics and hydrodynamics, was completed and began operating. The ship is used for DRB research activities and for co-operative programs with the Marine Sciences and Observations Branches of the Department of Mines, Energy and Resources and the Universities of British Columbia and Victoria. Construction of the somewhat larger CNAV *Quest,* displacement 2200 tons, commenced in 1967 and will be completed in 1969. *Quest* has been designed as a platform from which underwater acoustic experiments on echo ranging, propagation, reverberation and noise can be carried out. Two of her special features are the quietness of operation important today in both research and military ships - almost all the techniques of noise reduction developed for quiet submarines have been applied to the machinery and hull - and the ability to handle large heavy equipments over the stem and to suspend them at depths to 15,000 ft.; this capability, which has been developed by DREA, is unique in the Western World. The experience obtained from the design of the special features required for quiet silent operation will be valuable in the development of quiet ships for military use.

49. The 17-ton hydrofoil craft BADDECK has been reconfigured as a high speed (30 kt) towing facility fitted with a winch, over-the-stern towing sheave which can be oscillated vertically to simulate the effect of ship motions on a cable towed system, and instrumentation. She has open water towing research capabilities which are unique in North America and these are being exploited in a number of investigations, one of which is a co-operative US-Canada program on faired tow cables.

50. *Steel Pressure Vessel.* In support of acoustic research with equipment at great depths in the ocean, DREA has developed a special high pressure facility for testing the watertight integrity of equipment and the acoustic performance of sound generators at simulated ocean depths to 18,000 ft. The steel pressure vessel weighs 28 tons with a wall thickness of 7½ inches and a chamber 3 ft. diameter by 8 ft. deep, the size of the vessel makes it possible to place a

whole system under pressure rather than the usual procedure of testing the individual components of a system.

51. *Indoor Ballistics Range.* At CARDE a modern small caliber indoor ballistic range for testing new designs of shot and sub-calibre projectiles was completely renovated during this period. It is equipped with ballistic instrumentation of advanced design and is unique in Canada.

52. *Battery Research Facilities.* At DCBRE environmental and cold chambers were added during this period to permit in-laboratory studies of battery performance under conditions encountered by the Forces. No other agency in Canada has such facilities for battery research.

53. *Shock and Blast Facilities.* During this period DRES built shock tubes and blast simulation facilities for the investigation of basic blast phenomena and the response of equipments to blast. The working sections vary in size from a few square inches up to 6 ft. in diameter. These facilities are unique in Canada and are used from time to time in co-operative programs with universities in Alberta and Saskatchewan, as well as for studies related to National Defence problems.

54. In the past few years the DRES 1000 sq. mile area has been extensively developed by the installation of several well serviced and well instrumented test layouts, which are unique in Canada. In parallel, associated modern measurement systems involving electronic and photographic recording, and chemical and microbial sampling and analysis, have been developed. Some of the methods are of direct value in studying atmospheric pollution problems as evidenced by help and advice given recently to the Department of Energy, Mines and Resources and to two Canadian industries.

55. *Meteorological Tower.* A 300 ft. meteorological tower, situated in the 1000 sq. mile test range, is unique in Western Canada. The tower is instrumented to measure continuously the wind velocity and temperature profiles, and the stability of air masses at eight heights. The facility is ideally suited for carrying out meteorological research on a mesoscale over prairie terrain, the

results of which will complement those obtained on similar towers in Eastern Canada. Dispersal devices used in particulate and gaseous atmospheric diffusion experiments are also mounted on the tower. The Alberta and Saskatchewan universities and research councils are most interested in this facility and are presently discussing co-operative programs with the Meteorological Branch, DOT, for the use of the tower for the investigation of problems in basic meteorology and atmospheric pollution.

56. *Hyperbaric Wet and Dry Chamber.* The new DRET hyperbaric chamber accommodates experimental studies in water and various gaseous atmospheres at pressures varying up to the equivalent of a depth of 300 ft. in the sea. This research in pressure physiology is related to both military and civilian operations.

57. *Telecommunications Facilities.* In the last five years DRTE has designed and built one large fixed ground station, and two smaller terminals (one fixed and one mobile) for satellite communications research and experimentation.

58. In 1963, DRTE required a large steerable antenna for studying super-high-frequency propagation effects on space-earth communications. The state-of-the-art for large steerable antennas was reviewed and specifications were written for a 30 ft. precision tracking antenna, this size being a reasonable compromise between cost and performance. A contract for the antenna and associated equipment was let to the Northern Electric Company in July, 1964, and was completed in March of 1966 at a cost of about $1,000,000. This research facility is equal to any in the world.

59. In 1967, the Canadian Forces and DRTE agreed to participate in a NATO program of military satellite communication tests at UHF. To provide an immediate Canadian capability DRTE constructed two UHF terminals in under two months, using equipment and instruments available at DRTE plus $10,000 cash expenditure. One terminal is transportable, while the other is a high-performance, fixed terminal. These terminals are now being used for tactical communication trials and propagation measurements through the ionosphere.

60. In addition to these unique facilities DRTE has acquired or developed the following special facilities:

- a high frequency direction finding facility,
- a computer-aided design facility for electronic circuitry,
- a microelectronic facility for studying problems in developing integrated circuits and failure mechanisms,
- a facility for preparing exotic materials for use in solid state circuitry and lasers,
- a unique system of large-area antenna and transmitter complexes at Ottawa, Churchill and Resolute Bay for studying low frequency transmission.

61. *Alouette Satellites.* Although one might not immediately think of the Canadian satellites as research facilities, the fact is that they are, for both engineers and scientists in many fields, and they do indeed qualify as unique and valuable research facilities.

DRB's IMPACT ON ADVANCEMENT OF SCIENTIFIC KNOWLEDGE AND ECONOMIC DEVELOPMENT

62. As has been explained earlier (Annex II) DRB is a mission-oriented organization and, as such, the advancement of scientific knowledge is a means rather than an end. Similarly, its responsibilities for Canadian economic development are restricted. Nevertheless, its scientific activities have made significant and important contributions to advances in science and to economic development.

63. *Major Scientific Contributions.* The identification and description of the totality of DRB's contributions to science would require consultation with a majority of the Board's scientists, for these are the persons who together, know both the number and the quality of its research outputs. These scientists are located across the country and the time available for the preparation of this brief did not permit such consultation. Furthermore, the true value of most scientific contributions is not clear until considerable time has elapsed. Consequently this section does not list all the major accomplishments but a selection, which it is hoped, will illustrate the major contributions DRB has made to science.

64. Over the past 20 years DREA has been a major contributor to the international pool of scientific knowledge of the oceanography of the North Atlantic. DREA has made significant contributions to the science of underwater acoustics and has attained an international reputation in this field. This has been the result of intensive research aimed at obtaining quantitative values for the many variables which affect the propagation of sound through the ocean. During the past seven years, the effort has been concentrated on measurement of the acoustic properties of the deep ocean and the results are of significance to the field of marine biology as well. Their contributions have been so significant to the operational performance of long range sonar that the leader of the team is consulted frequently by the US Navy.

65. Basic studies at CARDE of atmospheric radiation propagation using aircraft, balloons, rockets in addition to ground observations have contributed the following:

(i) a better understanding of the mechanism of the hydroxyl airglow through observations of its diurnal variation and the temperature of the emitting layer,

(ii) evidence of seasonal, latitudinal and other, so far uncorrelated, variations in the stratospheric, water-vapour abundance,

(iii) development of the ramifications of a more satisfactory theory of ozone photochemistry which considers the catalytic effect of atmospheric water-vapour,

(iv) stimulation of the research programs in several Canadian universities.

66. The aim of the aerology program at CARDE, is to delineate the mechanisms which govern the interactions of infrared and visible radiation with the atmosphere and of applying this knowledge to military techniques involving natural or artificial sources of radiation.

67. A sweat rate measuring device (Sudorimeter) and techniques for using the data provided by it has been developed at DCBRE. This instrument can be used

to study the heat stress of protective clothing, the suppressive effect of drugs on the sweating reaction and the consequent disturbance of thermal equilibrium of the body, mental and emotional sweating patterns, and so forth. A commercial model has been developed in Canada, with support from Canadian Patents and Development Corporation, and the manufacturer has orders intended for a wide variety of applications by University and Hospital laboratories in Canada and the US.

68. Chemical dosimeters have been developed at DCBRE that will detect less than 0.1 rads of ionizing radiation and which are independent of the nature of the radiation whether it be neutron or gamma of any practical energy. These systems are the most sensitive aqueous, and therefore tissue equivalent, dosimeters so far developed and have been used for many biological studies.

69. The work at DCBRE on radiation transport enjoys a wide reputation for excellence, particularly on interface effects. A member of the laboratory staff is, at the request of the US National Academy of Sciences, a full member of the Sub-Committee on Radiation Shielding of its Advisory Committee on Civil Defense.

70. Major contributions have been made by DCBRE to improve the quality and reliability of primary and secondary batteries, the nickel-cadmium power supplies for the Alouette satellites being noteable examples. A coulometer-charge control device has been patented on a world-wide scale and is being extensively applied in the aircraft industry particularly.

71. Significant theoretical advances have been made by DRTE in the following areas: auroral and ionospheric physics; the propagation, scattering, and absorption of radio waves; upper atmospheric motions; solar-terrestrial relations; interactions between waves and energetic particles; communication systems, including information theory, and solid state physics.

72. In the very-high-frequency band, studies were conducted on radio wave scattering which led to the development of a communciation system based on meteor bursts. In such systems, reliable long-distance results are achieved by scattering the radio signals from ionized meteor trails. Theoretical studies of

the ionization properties of meteor trails supported this development and, at the same time, made a significant contribution to the knowledge of meteors. Theoretical studies of modulation methods and information theory were also required and such work has continued at DRTE ever since, and has been associated with a wide variety of communication systems.

73. Considerable progress has been made in studies of atmospheric motions, at heights above the normal weather systems. The theory of propagation of "gravity waves" was expanded and applied to a wide variety of upper atmospheric phenomena including atmospheric tides and turbulence. (The Royal Meteorological Society awarded C.O. Hines the Napier Shaw Memorial Prize in 1962 for his work on these topics.) Another series of studies dealt with motions of the earth's outer atmosphere, with specific application to auroral, geomagnetic, and trapped-particle processes. Hydrodynamics concepts, based on the assumption of a fluid-like convection of the tenuous ionized atmosphere around the earth, were formulated to account for the main features of auroral and magnetic storm observations. Subsequent to the introduction of this theory much new observational material was gathered and the theory requires modification; nevertheless, the convection concept is an integral part of most of the present auroral theories, and the DRTE work has stimulated activity by theorists elsewhere.

74. A series of studies on the scattering of radio waves by individual electrons (sometimes called incoherent scattering or Thomson scattering), showed how the scattered signals could be used to investigate the composition and properties of the upper atmosphere. These studies have since been extended by other workers, and major observational programs (based in part on the DRTE theoretical work), are now being pursued at stations in a number of countries.

75. In connection with experimental studies on radio wave absorption in the ionosphere, theoretical studies were made on the ionization effects of very energetic solar particles (sometimes called solar cosmic rays) at high latitudes, in an effort to explain in a quantitative way the phenomenon known as 'polar blackouts'. These communication blackouts are caused by solar events of particular importance to space and military operations, not only because of their disruptive effect on communications but also because the solar cosmic

rays are potentially hazardous to spacemen and space equipment. The early DRTE recognition of the importance of these phenomena led to the first major statistical studies of their occurrence, and to the development and installation of ground equipment for identifying and studying the solar particle events.

76. The launching of the Alouette I satellite with its ionospheric sounder and very-low-frequency receiver, made possible the first observations of ionospheric resonances. These observations stimulated considerable theoretical work by ionospheric and plasma physicists both in Canada and abroad, to explain the initiation and nature of such resonances.

77. About 200 scientific papers based on Alouette data have been published to date by scientists all over the world. Some of the highlights of the scientific results obtained by Canadian scientists are summarized in Annex IX.

78. DRB's program in the biosciences is relatively small and covers but a small part of the field. It has been deliberately limited to the problems of the healthy soldier and does not include much of what is usually considered to be medical research. It is concerned, primarily with such things as protective equipment and clothing for operational, hostile and toxic (NBC) environments, human engineering, training, NBC effects on man, and so on. DRB's work in these areas of the biosciences is respected both nationally and internationally. In the pure defence sciences associated with NBC defence, the contributions of DRES and DCBRE have earned great respect within the international defence science community. The three examples which follow demonstrate the impact of our research in areas less closely related to classified information and therefore of more general scientific interest.

79. Although oxygen is necessary for life, it becomes toxic at pressures greater than 2 atm for pure oxygen and at equivalent partial pressures in mixtures with other gases, e.g. nitrogen. This places severe limitations on the use of oxygen in diving operations and submarine escapes. Toxic effects are focused on the central nervous system and lead to convulsions and death. The biochemical mechanisms involved in oxygen poisoning defied delineation for almost 100 years but significant advances toward understanding them have been

made by DRET scientists. They have demonstrated that oxygen poisoning inhibits the enzymes responsible for the formation of a particular amino acid unique to the nervous system. Promising studies have been carried out on a prophylactic chemical to protect against oxygen poisoning. This work has received international recognition, as witness an invitation to present the results of the work to a very select international group which met in Austria in 1967.

80. Research in motion sickness at DRET, revealed that angular accelerations of the head, are of prime importance in the development of motion sickness, and that its incidence can be dramatically reduced by restricting movement of the head relative to the body. DRET also developed practical applications of the results to aircrew problems. The scientific importance of this work has received international recognition on several occasions and the US has employed DRET experts as consultants to their astronaut program.

81. The third example from the biosciences field, concerns DRB research over many years on the human engineering aspects of radar operators' efficiency. The book on this subject, written by DRET scientists, is the standard reference book and their expertise was internationally recognized to the extent that the US Department of Justice consulted DRET personnel during the investigation of the Andrea Doria - Stockholm collision.

82. In the field of geophysics, mention has already been made (paragraph 40), of the contribution of the team engaged in research in the high Arctic. Another example in this field is the result of an exhaustive examination of the craters formed during the multi-ton explosions of the shock and blast program at DRES, especially that of a 500 ton explosion in 1964. This crater proved to have a striking resemblance to impact craters on the moon and on earth, and proved to be of the greatest interest to geophysicists and astronomers. The very complete instrumentation for this explosion has resulted in a very good understanding of the forces at work in forming the crater.

83. The final example is provided by DREP's long term research in low frequency magnetics. This research has centered on the naturally occurring fluctuations of the earth's magnetic field (known as micropulsations) and the electro-

magnetic signals produced by ocean waves. Since this research started in 1955, DREP has published more than 20 papers in the scientific journals and has become recognized as an international authority in the phenomenological aspects of micropulsations. Working in co-operation with several University groups (UBC, McGill, UVIC and Stanford), enabled DREP to gather experimental data from widely separated geographical locations.

84. In recognition of its competence in the field of low frequency magnetic phenomena, DREP has been invited to participate in several International Symposia in the field of Geomagnetism, Magnetometry, Oceanographic Instrumentation and Non-Acoustic Methods of Detection.

85. *Impact on Economic Development.* While there is no doubt that DRB's scientific activities have had important impacts on economic development, it is impossible, for lack of data, to identify all, or even the majority of the instances where DRB research has been of benefit to economic development. There are several reasons. DRB has no direct involvement in the exploitation of the products of research except in a consulting role. Another is that DRB's part will not have been solely or even primarily responsible for the success of ventures in which their results were applied.

86. The regional distribution of DRB's intramural scientific activities were treated in Annex IV and the size and regional distribution of its extramural programs was given in Annex VII. The funds expended on these programs have had a *direct* impact in proportion to the amounts spent. The indirect impacts cannot be measured but it is possible to give some indication of their magnitude. The best of the estimates that follow are derived from the defence industrial research and satellite programs in which DRB has been directly and deeply involved with the industrial producers.

87. The following Table lists examples of production orders known to us which can be related to DRB research results. A large proportion of the value of these orders represents export sales.

SOME KNOWN ECONOMIC BENEFITS OF DRB WORK

FIELD	*KIND OF ITEM*	*PRODUCTION ORDER VALUE (millions of $)*
Telecommunications	Antennas	2.75
	Ionospheric Sounding Equipment	4.0
	Meteor Burst Comm. Systems	1.25
	Oblique Sounding Comm. Systems	5.0
Navigation	Airborne Doppler	100.0
Electronics	Components	26.45
Armament & Weapons	Anti-Tank	10.85
NBC Defence	Protective Clothing & Equipment	1.07
	Respirators	3.17
	Radiacmeters	4.5
Batteries	Torpedo	2.25
	Sarah Beacon	1.0
Antisubmarine Warfare	Sonar	33.0

88. The following five examples give an indication of the impact of the defence industrial research program on economic development.

(i) *CAE Industries Limited*, a Canadian-owned company in Montreal, entered the field of digital flight simulators at the direct instigation of DRB, the initial impetus being supplied by a DIR grant in this area. As of 4 July 1968, the company had sold over $18 million worth of digital flight simulators, nearly all of them to overseas customers, in the face of severe foreign competition. Since these were all sold to civilian airlines, this is an excellent example of "civilian spin-off" from a defence research project. They have also submitted bids for military simulators.

CAE have also done considerable business in the field of Magnetic Anomaly Detection, attributable in part at least to DIR-supported

research. A total of $8.5 million of MAD compensating equipment, training systems and devices has been sold to date, of which $4 million was to foreign customers, mainly the US Navy.

(ii) *DeHavilland Aircraft of Canada Limited,* has received DIR support since the earliest days of the program, for research in the STOL and VTOL fields. The results of this program have contributed to the success of the Buffalo and Twin Otter STOL utility aircraft, and have helped the company retain its position as a world leader in this field. The company has, in fact, stated in writing that the Buffalo and Twin Otter aircraft would not have been competitive without DIR support. These STOL utility aircraft are employed in both commercial and military roles, and several hundred have been sold, mostly to foreign buyers throughout the world.

(iii) *United Aircraft of Canada Limited,* has received DIR support for an extensive program of research to improve the performance of various engine components such as turbines and compressors. These programs have made important contributions towards the improved performance of the latest version of the PT6 turboshaft engine, and are basic to the design of the JT-15D 2000 lbs. thrust turbofan engine now under development. UACL has an acknowledged position as one of the world leaders in the small turbine field and has a very impressive record of export business for both military and civilian applications. It has been predicted that total sales of the PT6 engine alone will reach $500 million.

(iv) *Northern Electric Company Limited,* is a Canadian-owned company located near Ottawa, which supplies most of the switching and control equipment to the Bell Telephone Company of Canada Limited. They have had a broad, DIR-supported program since 1962, mainly for research in the area of thin-film circuits and silicon integrated circuits. This support has been an important factor in helping the company establish one of the best industrial research and development facilities in Canada in this field. The success of the R&D program has induced Northern Electric to

construct a manufacturing plant in Ottawa for integrated circuits, incorporating the most modern techniques, with assured large orders from Bell Telephone.

On the military side, the company has been able to submit proposals on several advanced systems, and has obtained NATO and US contracts. In all these cases, the results of the DIR-supported research were directly relevant and could be exploited.

(v) *Ferrox Iron Limited*, was formed in 1964 as a subsidiary of Quebec Smelting and Refining Limited, to develop and exploit new processes for the production of improved ferrite powders for military and commercial applications. A new plant was built at Prescott with DDP assistance, and a DIR grant was awarded for research in ferrites. Progress has been excellent, and has induced the parent company to set up a $3 million plant at Sydney, N.S., which will employ 250 people at peak production. An $860,000 plant has also been set up at Ogdensburg, N.Y. for storage and sales to the US. In addition to this work on ferrites, the parent company has entered into a partnership with Canadian Petrofina Limited, to set up a new $4 million plant in Montreal (Fina Metals Limited), to produce 50 tons of pure iron powder per day. The successful DIR-sponsored research has been a basic factor in all these plans for commercial exploitation.

89. Although in the future the responsibility for the satellite program will rest with another department some historical facts regarding the economic impact of this program seem appropriate to this brief.

90. Alouette I was designed and built completely within the Defence Research Telecommunication Establishment. While Alouette II was also designed and constructed at DRTE, the opportunity was taken to bring industry into DRTE to provide training for industry in satellite technology. ISIS-A is being designed and constructed mainly by the contractors (RCA Victor Company Limited and DeHavilland Aircraft of Canada Limited), at the contractor's plant in Montreal, but with DRTE retaining responsibility for the overall system design, command

system design, and for a few sub-systems in which DRTE engineers have particular expertise. One aim of the program, that of up-grading Canadian industry so that it will be in a position to design and build complex satellites, is thus being achieved.

91. The number of engineers and support staff concerned with the design and construction of the spacecraft in industry is of course not constant. In 1967, there were 52 engineers and scientists and 57 support staff (technicians, draftsmen, etc.), engaged on the program. As a result of the ISIS program, skills have been either introduced or strengthened in the companies involved.

92. On the operating side involving spacecraft already in orbit, there are 17 operators and 10 scalers employed from industry, who have acquired the special skills related to such things as operation and maintenance of telemetry stations and satellite control operations and scheduling.

93. Accurate figures for orders received by the contractors are difficult to obtain, but it is known that DeHavilland have sold STEM devices (antennas, experimental booms, gravity gradient booms), for a total of at least 2¾ million dollars, most of which has been exported into the US. RCA Victor have supplied telemetry transmitters for two American aircraft.

94. A domestic market for space products is developing in Canada and will probably be more important than the export market in the long term. The study completed for the Science Secretariat of the Privy Council Office, on "Upper Atmosphere and Space Programs in Canada", disclosed that the use in Canada of satellites for communications within Canada is foreseen by telephone companies and the CBC as necessary and profitable. The USA is trying to monopolize the communications satellite market and thus move into Canadian domestic communications; the annual rental of satellite channels could cost $100 million by 1980. Canada will have to manufacture her own communications satellites to retain Canadian control of communications in Canada and to keep this money in Canada.

95. Scientists at Canadian universities are also becoming users of communications satellites. The ISIS-B experimenters from the Universities of Saskatchewan

and Calgary, both propose contracting with RCA Victor for the design and construction of the equipment for their experiments.

96. Three remarks seem appropriate in concluding this section on scientific and economic benefits of DRB's activities. Firstly, all these benefits are bonuses unrelated to DRB's reason for existence, its primary objectives, and its nature as a research organization, which has neither the responsibility nor the means for the exploitation of its research results. Secondly, the economic benefits constitute a respectable amount considering that at least half its manpower and budget have been devoted to areas which seldom lead to production of equipment, e.g. the biosciences, operational research oceanography, geophysics, field trials, etc. Thirdly, the economic benefits do not include millions of dollars known to have been saved as a result of improvements to Canadian Forces equipment and components which made them cheaper to produce, cheaper in maintenance and training costs, and gave them longer service life.

ANNEX IX — PROJECTS

PROJECT LISTS

1. Tables 1, 2 and 3 list the project titles for the University Grants Program, the Defence Industrial Research Program and the Intramural DRB program for the years 1962-67. The projects in Tables 1 and 2 are not listed by establishment because in the period 1962-67 the grants were the responsibility of DRB headquarters. They are listed by the scientific disciplines used in Annex VI. The projects in Table 3 are listed by establishment and grouped by program, the titles of which are self-explanatory.

CASE HISTORIES

2. Appendix A presents case histories of some selected intramural projects.

TABLE 1 — List of University Research Grants

A — ENGINEERING AND TECHNOLOGY

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
1. Electrodeposition of metals	x	x	x	x	
2. Thermodynamic aspects of the chromizing process		x	x	x	x
3. Preparation of dried milk powder	x	x	x		
4. Preparation of dried cheese	x				
5. Propulsion studies	x	x	x		
6. Transport phenomena in fluid jets	x				
7. Effect of wall temperature on flow in bends	x	x	x		
8. Turbulent mixing due to falling spray	x	x	x	x	x
9. Aerodynamics of lifting surfaces translating in proximity to the ground	x	x	x		
10. North Water Planning Project					x
11. Studies relating to the design of towed underwater bodies					x
12. Structure and properties of composite materials		x	x	x	x
13. Phase transitions in mixed oxide crystals					x
14. Very high power pulsed laser systems	x	x	x	x	x
15. Transient stress analysis due to high velocity impact				x	x
16. Mechanical properties and structural defects in soft martensitic steels					x
17. Investigation of spinning detonation and gaseous detonability limits		x	x	x	x
18. Boundaries in metals	x	x	x	x	x
19. Aerodynamic noise of a disturbed mixing layer					x
20. Investigation of the information content of speech in relation to frequency compression	x	x	x		
21. Contributions to data-processing systems	x	x	x		
22. The dynamic response of structural elements to impulsive or transient loads					x

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

Title	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
23. Vibration analysis of space frames					x
24. Rates of removal of gases dissolved in metals by bubbling inert gas					x
25. Transient flow in branched ducts					x
26. Electrical and magnetic properties of semiconductors, intermetallic compounds and organic materials					x
27. A study of control systems incorporating time-lag modulation					x
28. Transient and random processes in non-linear electrical oscillators	x	x			
29. Heterocharge in electrets	x	x	x	x	
30. Charge decay in electrets	x	x	x		
31. Transistorized sampled data analogue memory using magnetic care storage	x	x	x		
32. Noise threshold effects in a phase-lock tracking filter	x				
33. Study of tunnel triode and unequal band-gap junction	x	x	x	x	x
34. Optical masers	x	x	x	x	x
35. Ferroelectric ceramics	x	x	x	x	x
36. Determination of certain properties of various substances having high melting points				x	x
37. Transient and random processes in non-linear and time-varying systems	x	x	x	x	
38. Adaptive filter for correction of signal distortion	x	x	x	x	
39. Effect of wavefront coherence on design of hydrophone and antenna arrays			x	x	x
40. High-gain, low current transistors		x			
41. Vibration response of bridge structures to dynamic loads			x	x	x
42. Production and properties of reactive metals	x				
43. Mechanism of tempering reactions by internal friction	x	x	x	x	x
44. Phase transformations in titanium alloys	x				

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

	Years Project Active				
Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
45. Structure and mobility of grain boundaries	x				
46. Structure and properties of metal-ceramic bonds	x				
47. Growth and properties of metallic whiskers	x				
48. Effects of strain-rate and temperature on deformation behaviour	x				
49. Effect of various factors on fatigue life of metals	x				
50. Cyclic stressing of high-strength light alloys		x	x	x	x
51. Use of an electromagnetic pump to improve precision casting			x	x	x
52. The determination of turbulent skin friction					x
53. Effect of temperature and surface finish on heat transfer	x	x	x		
54. Absorption of thermal radiation of liquids on porous surfaces	x	x	x	x	x
55. Edge and cut-out effects in thin structural shells	x	x	x	x	x
56. Large deflections of skewed plates		x	x	x	x
57. Secondary flow generation in rotating impeller passages				x	x
58. Polymer films with selective permeability and barrier properties					x
59. Analysis of ship systems					x
60. A direct method of measuring the velocity of sound in water				x	x
61. The production of uniform-sized drops in liquid-liquid systems		x	x	x	x
62. Studies of shock flows					x
63. Flow in bends in non-circular ducts				x	x
64. Investigation of the ultimate capacity of columns in a framework subject to biaxial loading	x	x	x	x	x
65. Four terminal filter			x		
66. Construction of an electronic computer	x				

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
67. Fluid dynamic investigations at very high pressures	x	x	x	x	
68. Investigation into carangiform propulsion			x	x	x
69. Solar wavelength radiometer for surface property determinations			x	x	x
70. Investigation of methods for the control of transition and separation of liquid layers					x
71. The effects of environment and oxidation in modifying the creep behaviour of stainless steel				x	x
72. Mass spectrometric determinations of the heavy elements in low level detection work	x	x	x	x	
73. Decay-time components in scintillators	x	x	x	x	
74. Viscoelastic die blanking of sheet metals				x	x
75. Instability conditions in high velocity deformation of ductile metals				x	x
76. Theoretical and experimental investigations of field effect phenomena in thin semi-conducting films			x	x	x
77. Minimal rate of fluidisation and free-fall velocity				x	x
78. Electronics Research Program — Eaton Electronics Research Laboratory	x	x	x	x	x
79. Effects of heating rates in the annealing of low carbon mild steel	x	x			
80. Mechanical properties of thin metallic films	x	x	x	x	
81. The mechanism of stress corrosion cracking	x	x	x		
82. Relationship between fatigue and micro-structure in aluminum	x	x	x		
83. Survey of the scientific progress made in the field of plastic wave propagation		x	x	x	
84. Grain refinement in metals			x	x	
85. Curve fitting by perturbation methods	x				

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
86. Trajectory calculations	x	x			
87. Digital computing systems			x	x	x
88. Electro-magnetic power modulators			x	x	x
89. Thin film device research			x	x	x
90. The influence of surface finish on the wear of steel surfaces under boundary lubrication conditions	x	x	x	x	x
91. Mechanism of wave formation in high energy welds					x
92. High velocity impact of rock					x
93. Fire retardants in cellulose				x	x
94. Analysis and synthesis of automatic control systems	x	x	x		
95. Control systems and electronic computing techniques	x	x	x		
96. Non-linear parameter-insensitive control system	x	x	x		
97. New multi-sensor techniques for air reconnaissance	x	x	x	x	
98. Topographical survey of curved aerodynamic surfaces					x
99. Structural responses to dynamic forces	x	x	x	x	x
100. Investigations of pure relations on a digital computer					x
101. Study of relay control systems				x	x
102. Microelectronic research					x
103. The effect of shape on the stress-resultants and deformations in shells of revolution				x	x
104. Numerical solutions in fluid mechanics					x
105. Millimeter wave optics			x	x	x
106. Signal processing in low-frequency systems					x
107. Response of underground structures to blast loadings		x	x	x	x
108. Deformable bodies and fluid flow	x	x	x	x	x
109. Structures and properties of alloys based on intermetallic compounds				x	x

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
		Years Project Active			
110. Comportement d'un filtre de masse quadrupolaire					x
111. Self-adaptive and self-optimizing control systems			x	x	x
112. Photoelastic analysis of plates			x	x	x
113. Development of a vortex type magneto hydrodynamic induction generator			x	x	x
114. Gravity gradient libration of a rotating ring type satellite					x
115. Investigation of unsteady magneto-gasdynamics					x
116. Propulsion Studies	x	x	x	x	x
117. Engineering properties of frozen soil	x	x	x	x	x
118. Steady and non-steady flow about wings at high incidence	x	x	x	x	x
119. Mechanism of hardening in metals	x	x	x	x	x
120. Semiconductor radiation detectors				x	x
121. Research in basic aerodynamics	x	x	x	x	x
122. Aerodynamic investigations	x	x	x	x	x
123. Fundamental mechanics of metal cutting and forming processes	x	x	x	x	x
124. Coupling of acoustic energy in bars and plates					x
125. Conduction band structure of III-V alloys					x
126. An adaptive method of encoding signals				x	x
127. Investigation of the effects of an initial gap on the flow in a wall jet				x	x
128. Stress analysis of slit, long thin-walled tubes					x
129. Deformation processes in materials		x	x	x	x
130. Theoretical and experimental research on antennas	x	x	x	x	x
131. Dynamic response of ring structures					x
132. Experimental reduction of auto-kinetic movement				x	x

TABLE 1 — List of University Research Grants (Cont'd)

A — ENGINEERING AND TECHNOLOGY (Cont'd)

Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
	Years Project Active				
133. The measurement of hypersonic gas velocities	x	x	x	x	x
134. Semiconductor behaviour in microwave and high electric fields		x	x	x	x
135. Low speed fluid dynamics research	x	x	x	x	x
136. The deposition of solids and the study of erosion by means of a plasma jet				x	x
137. In-process measurement of machining	x	x	x		
138. Explosive shock waves and their effects on structures			x	x	x
139. Control of induction motor characteristics using cyclically switched silicon control rectifiers				x	x
140. Non-linear multivariable control systems				x	x
141. Fatigue of metals				x	x
B — ATMOSPHERIC SCIENCES					
1. Reactions of the constituents of the upper atmosphere	x	x	x	x	x
2. Radio star scintillations	x	x	x	x	x
3. Wind and temperature characteristics of the stratosphere					x
4. Ionospheric studies using satellites		x	x	x	x
5. VHF radio wave scattering in the ionosphere	x	x	x	x	x
6. Atmospheric research	x	x	x	x	x
7. Physics of the troposphere related to UHF radio transmission	x	x	x	x	x
8. The infrared emission spectrum of the upper atmosphere	x	x	x	x	x
9. Ionic constituents in the ionosphere	x	x	x	x	x
10. Radio measurements of effects of solar flares	x	x	x	x	
11. Micrometeorlogical studies in Canadian forests	x	x			
12. Solar radio noise patrol with high resolution direction-finding interferometers					x

TABLE 1 — List of University Research Grants (Cont'd)

C — BIOLOGICAL SCIENCES

Title	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
1. Effect of radiation on virus vaccines	x	x	x	x	x
2. Studies of aerosols of viruses and of virus extracts	x	x	x	x	x
3. Toxicity of aerosols	x	x			
4. Current susceptibility levels and the potential for resistance to insecticides in fabric and stored product insects	x	x	x	x	x
5. Aerial interpretation of the ecological method	x	x	x	x	x
6. Factors affecting the viability of bacteria under physical stress		x	x	x	x
7. Dynamics and morphology of the biting midge, *Culicoides obsoletus* Meigen (Diptera: Ceratopogonidae)					x
8. Mosquito abundance in relation to weather and irrigation in Saskatchewan		x	x	x	x
9. Metabolism of dextran	x	x	x	x	x
10. Behaviour of biting flies with special reference to orientation and feeding	x	x	x	x	x
11. Pharmaceutical investigation of certain oximes	x	x	x	x	x
12. Rapid identification of virus agents in the atmosphere			x	x	x
13. Reaction of organophosphorus compounds with serine esterases					x
14. The influence of genetic change on the stability of airborne microbes					x
15. The reactive principles and specificity of bites of blood sucking arthropods with particular reference to mosquitoes	x	x	x	x	x
16. Movements of p^{32} tagged adult blackflies					x
17. Cooperative studies in biological effect of high energy pressure vibrations	x	x	x		
18. Biological significance of sound production in marine fishes				x	
19. Kinetic studies of enzyme systems	x	x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

C — BIOLOGICAL SCIENCES (Cont'd)

Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
	Years Project Active				
20. The relationship of radiation stability to carotenoid content in certain bacteria					x
21. Zoogeography of northern aedine mosquitoes: effect of developmental temperatures in determining the southern limit of distribution				x	x
22. To separate and identify the active principle of mosquito saliva					x
23. Ballistics of arm and hand in relation to accuracy of purposeful movement under varying accelerations		x	x	x	x
24. Resistance of irradiated animals to tuberculous infection				x	x
25. Mode of action of insect repellants	x	x	x	x	x
26. Factors affecting the viability of airborne microorganisms	x	x	x	x	x
27. Rapid identification of bacteria	x	x	x	x	
28. Retrocerberal endocrine system of prairie mosquitoes	x	x	x		
29. Studies on the morphology of FORCIPOMYIA		x	x	x	x
30. Studies on the immature stages of SIMULIUM RUGGLESI		x	x	x	x
31. Insecticidal area-barrier studies	x	x	x	x	
32. Studies of attractancy in black flies			x	x	x
33. Studies on repelling blood-sucking insects	x				
34. Biting flies: flight range	x	x	x	x	x
35. Factors in attractiveness of objects to adult AEDES AEGYPTI	x	x	x	x	x
36. Field studies on mosquito biology	x	x	x		
37. Studies on ecology of SIMULIUM RUGGLESI	x	x			

TABLE 1 — List of University Research Grants (Cont'd)

D — CHEMISTRY

Title	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
1. Catalytic reactions in gas mixtures					x
2. The shift in vibration bands of some molecules, NH_3, ND_3, HCl, N_2O, in the solid phase				x	x
3. Molecular motions in solids and liquids	x	x	x	x	x
4. Studies of disperse systems			x	x	x
5. Interferometric study of basic transport phenomena		x	x	x	x
6. Chemical reactions of diethyl-diphenylurea					x
7. Nature and reaction of an excited oxygen molecule	x	x	x	x	x
8. Reactions of hydrazine with Lewis acids	x	x	x	x	x
9. A nuclear magnetic resonance study of some properties of single crystals	x	x	x	x	x
10. Study of P-C-N polymers and the flame-proofing effect of such polymers on cellulose materials				x	x
11. Studies of the derivatives of chromic acid					x
12. Structure of phosphorus compounds				x	x
13. Metal complexes	x	x	x	x	x
14. The relationship of intercomponent bonding to the physical properties of polymer composites					x
15. Anticholinergic reactivators of the phosphorylated cholinesterase					x
16. Molecular spectra in the far ultraviolet					x
17. Oxidation of metals and alloys	x	x	x	x	x
18. Investigation of the acidity of concentrated perchloric acids			x	x	x
19. Studies on active nitrogen	x	x	x	x	x
20. Explosives research	x	x	x	x	x
21. Mechanism of aerosol coagulation	x	x	x		
22. A study of the early stages of oxidation in pure metals					x

TABLE 1 — List of University Research Grants (Cont'd)

D — CHEMISTRY (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
23. Studies on the synthesis and properties of perfluoro-alkyl silicones		x	x	x	x
24. Inorganic heterocycles				x	x
25. Radiation chemistry studies by flash photoionisation				x	x
26. Biradical polymerization			x	x	x
27. Effect of dilute polymer solutions on frictional drag					x
28. Organo-boron compounds	x	x	x	x	x
29. The study of appearance potentials of gaseous molecular species by electron energy absorption		x	x	x	x
30. Radiation chemistry	x	x	x	x	x
31. Extractive distillation employing the salting-out effect		x	x	x	x
32. Effect of radiation on proteins			x	x	x
33. Reactions of hydrogen peroxide in the gas phase			x	x	x
34. Study of electrolyte solutions by microcalorimetry					x
35. Dye catalyzed photooxidation of diamines					x
36. The oxidation of lead sulphate to lead dioxide	x	x	x	x	x
37. Steric influences upon the packing of difunctional molecules	x	x	x	x	x
38. Hexanitroethane and related compounds					x
39. Organoboron compounds with several boron atoms			x	x	x
40. Studies of the thermal initiation of explosion in organic peroxides			x	x	x
41. Preparation of compounds antagonistic to inhibitors of cholinesterase					x
42. Properties of charcoal from plastics	x	x	x	x	x
43. Kinetics of fluoro-carbon compounds	x	x	x	x	x
44. Solid state properties of single crystals of semi-metals and metals		x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

D — CHEMISTRY (Cont'd)

Title	Years Project Active				
	62/63	63/64	64/65	65/66	66/67
45. Electrochemical studies on fuel cell reactions	x	x	x	x	x
46. Electrolytic oxidation and reduction of nickel hydroxides	x	x	x	x	x
47. Fluorocarbon derivatives of phosphorus			x	x	x
48. Reactions of gaseous ions					x
49. Intermediates in fast reactions occurring in combustion, explosions and the upper atmosphere		x	x	x	x
50. Microcalorimetry studies	x	x	x		
51. Stabilizer degradation in aged propellants	x	x	x	x	
52. Addition of nucleophiles to unsaturated systems	x	x	x	x	x
53. Physical chemistry of solid fuel propellants					x
54. Radiation chemistry and physics of solids	x	x	x		
55. Radiolysis of simple halogenated compounds	x	x	x	x	
56. Reaction in dissociated water vapour	x				
57. Thermodynamic properties of polyoxypropylene glycol solutions and their derivatives	x	x	x	x	x
58. Photochemistry and free radical chemistry of the boron hydrides	x	x			
59. The chemistry of solutions in fluoro-sulphuric acid and anhydrous hydrogen fluoride	x	x			
60. Nature of electro-deposited oxides	x	x	x		
61. Synthesis of 3-guanido-5-pyrazolones and 3-guanylamido-5-pyrazolones	x	x	x	x	x
62. Alkoxyl free radicals	x	x			
63. The reaction of excited nitrogen atoms	x	x	x		
64. Polymerization of aromatic hydrocarbons	x	x			
65. Studies on carbonium ions	x	x	x	x	x
66. Investigation of the free radical precursors in graft polymerization	x	x	x	x	

TABLE 1 — List of University Research Grants (Cont'd)

D — CHEMISTRY (Cont'd)

Title	Years Project Active 62/63	63/64	64/65	65/66	66/67
67. The reactions of sulphur tetrafluoride and the oxyhalides SOF_2 and SOF_4 with other inorganic fluorides		x	x	x	
68. The magnetic properties of transition metal soaps		x	x	x	x
69. Halogenated sugar acetals		x	x	x	x
70. Mechanical behaviour of crystal boundaries in metals at high temperatures	x	x	x	x	x
71. Radiolysis and protection of synthetic polypeptides in aqueous solution	x	x	x	x	x
72. Approaches to the synthesis of tetrodotoxin				x	x
73. Studies on polymer and pyrolytic carbons		x	x	x	x
74. A novel class of irreversible inhibitors of acetylcholinesterase: synthetic and mechanism studies			x	x	x
75. Calorimetric investigations				x	x
76. Growth and structure of evaporated films	x	x	x	x	x
77. High pressure polymerization of alkylene oxides	x	x	x	x	x
78. Preparation of deoxy sugars from monomercaptomonosaccharides					x
79. Study of the interaction of aromatic polynitro compounds with bases in aprotic solvents					x
80. Thermal diffusion in ion-selective membranes		x	x	x	x
81. The chemistry of water-repellent compounds	x	x	x	x	x
82. Reactions of thiyl radicals in solution					x
83. High temperature kinetics	x	x	x	x	
84. Photochemical reactions of organo-fluoro compounds	x	x			
85. Reaction of alkyl halides with PCL_3 and $ALCL_3$	x				
86. Stereochemistry of addition to activated double bonds	x	x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

D — CHEMISTRY (Cont'd)

Title	Years Project Active				
	62/63	63/64	64/65	65/66	66/67
87. Water-insoluble indicators	x	x	x	x	x
88. Photochemistry of amino acids			x		
89. Electrochemical properties of porous nickel electrodes	x	x	x	x	x
90. Cathodic deposition of zinc	x				
91. A study of gas phase reactions initiated by electrical discharges		x	x	x	x
E — MATHEMATICS					
1. Algebra and calculus on a small computer				x	x
2. Use of analogue computer in solution of non-linear systems of second and third order	x	x	x		
3. Minimax approximations theory		x	x	x	x
F — MEDICAL SCIENCES					
1. Cardio respiratory research in relation to aviation medicine	x	x	x	x	x
2. Category and magnitude scaling of sensory continua				x	x
3. Cardiovascular adjustments in shock	x	x	x	x	x
4. Clinical significance of unusual electrocardiograms of apparently healthy people	x	x	x	x	x
5. Virus diseases of military importance	x	x	x	x	x
6. Toxoids and blood sera	x	x	x	x	x
7. Repair processes occurring in maematopoietic tissue following total-body radiation	x	x	x	x	x
8. Physical properties and applicability of the RCAF earpiece for oximetry				x	x
9. Survey of viral respiratory illness, CFB, St. Jean			x	x	x
10. An electrical study of vestibular function	x	x	x	x	x
11. Metabolic reactions to dietary, temperature and traumatic stresses	x	x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

F — MEDICAL SCIENCES (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
12. Deposition of triorthocresyl-phosphate (TOCP) in the central nervous system				x	x
13. Infectious hepatitis and serum jaundice	x	x	x	x	x
14. The effect of helium on the respiratory gas exchange in humans				x	x
15. Hyperventilation in pilots of aircraft				x	x
16. Studies on rewarming shock					x
17. Effect of adverse environmental conditions on intellectual and perceptual processes	x	x	x	x	x
18. Effect of nutritional and other conditions on liver metabolism	x	x	x		
19. Dietary protein requirements for muscular activity (work)	x	x			
20. The effect of mannitol on renal function and its value in preventing renal failure	x	x	x		
21. A study of the allergens in cement dust	x				
22. Sulphydryl compounds and protection against radiomimetic alkylating agents				x	x
23. Experimental influence of agents affecting cellular and tissue metabolism on chemical toxicity and sensitization	x	x	x	x	
24. Study of the significance of the cardiac deficit in clinical shock					x
25. Studies on experimental shock	x				
26. The preservation of red blood cells by freezing				x	x
27. Study of the molecular size including size distribution and shape of plasma volume expanders	x	x	x	x	x
28. Factors influencing the toxicity of some organophosphorus compounds				x	x
29. DRB Aviation Medicine Research Unit	x	x	x	x	x
30. The use of short chain ribosides as blood preservatives	x	x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

F — MEDICAL SCIENCES (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
31. The role of sodium in the neuro-secretion of acetylcholine	x	x	x	x	x
32. Studies concerning western equine encephalitis in Saskatchewan	x	x	x	x	x
33. The neurophysiology of sensory-motor mechanisms	x	x	x	x	x
34. The study of the combined effects of thermal trauma and simulated fallout on early mortality in mice					x
35. Preservation of blood	x	x	x	x	x
36. Relations between the thyroid and cortico-adrenal glands in animals exposed to cold	x	x	x	x	x
37. Studies on decompression aeroembolism		x	x	x	x
38. Study of the pharmacological actions of pralidoxime					x
39. Vasospasm due to cold	x	x	x	x	x
40. The physiology of acoustic trauma, and the intra-aural reflex		x	x	x	x
41. Detection of anoxia as cause of death	x	x	x	x	x
42. Study of the site of action of steroids in cerebral oedema					x
43. Studies on clostridium botulinum toxins, toxoids and anti-toxins	x	x	x	x	x
44. Respiratory and cardiovascular responses to mixtures of O_2 and CO_2					x
45. Autonomic effects of vestibular stimulation					x
46. Regulation of heat production					x
47. Collagen metabolism in wound healing	x	x	x	x	x
48. The preservation of blood and plasma fractions in a liquid nitrogen refrigerator	x	x	x	x	x
49. Radiation Research Unit	x	x	x		
50. Arctic Medical Research Unit	x	x	x	x	x
51. Studies on accidental hypothermia		x	x	x	x
52. Physiological mechanisms involved in the oxygen paradox		x	x		

TABLE 1 — List of University Research Grants (Cont'd)

F — MEDICAL SCIENCES (Cont'd)

Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
		Years Project Active			
53. Hemodialysis in shock		x	x	x	
54. The brain stem mechanism underlying the control of directed postural reflexes			x	x	x
55. Perceptual thresholds of vertical acceleration in man				x	x
56. The effect of drugs affecting perceptive ability on neurons of the superior colliculi					x
57. Metabolism of sialic acid mucoproteins	x	x	x	x	
58. Biochemical mechanisms in adaptation to cold	x	x	x	x	x
59. Enzymic processes in human skin in health and in disease	x				
60. Studies of the acute radiation syndrome	x	x	x	x	
61. Evaluation of endothelial sealing agents in the treatment of thermal burns		x	x	x	x
62. The influences of Trasylol in late survival rates in experimental burns			x	x	
63. A mathematical model for pressoreceptor activity				x	x
64. The effect of diffuse dazzle on the field of vision			x	x	x
65. Transfer in motor skills	x	x	x		
66. Effect of blood CO_2 level on hemodynamic response to epinephrine and norepinephrine	x	x			
67. Development of a technique for obtaining long-term survival of bone marrow	x	x	x	x	
68. Histochemical evaluation of thyroid activity	x	x			
69. Pathological changes in the temporal bone and eighth nerve	x	x			
70. Relation between vestibular function and the autonomic nervous system	x				
71. Pathogenesis of fat embolism	x	x	x	x	
72. Studies of the vascular reactions in frostbite	x	x	x		

TABLE 1 — List of University Research Grants (Cont'd)

F — MEDICAL SCIENCES (Cont'd)

Title	Years Project Active				
	62/63	63/64	64/65	65/66	66/67
73. Studies of arbovirus antibodies		x	x	x	x
74. Effects of cold in pharmacological reactions	x	x	x	x	x
75. The effect on colour vision of various extraneous stimuli, such as noise	x	x			
76. A study of urinary peptides and micro-proteins in burn patients	x				
77. Resistance and acclimatization to cold	x	x	x		
78. Physiology of heparin	x	x	x	x	x
79. Reaction of men and animals to cold and damp	x	x			
80. Fission products metabolism	x	x	x	x	x
81. Studies on acclimatization	x	x	x		
82. Effect of changes in oxygen tension on sympatho-adrenal and other systems	x				
83. Functional organization of the mammalian visual system	x	x	x	x	x
84. Cardio-pulmonary function	x				
85. High oxygen effects on visual function	x	x			
86. Local and systemic circulatory adaptation to a cold stress stimulus in fishermen	x	x	x	x	x
87. Estimated blood flow after cold injury by means of an infrared imaging device	x				
88. Effects of anoxic anoxia at different environmental temperatures	x	x	x		
89. Radiation injury; early and late	x	x	x	x	
90. Reactions to plasma expanders	x				
91. Studies of the circulatory effect of CO_2 and hyperventilation	x	x	x		
92. Salivary secretion as index of "tension-fatigue"	x	x			
93. Electrographic analysis — syncopy, epilepsy	x				
94. Hypothermia and endocrine function	x	x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

F — MEDICAL SCIENCES (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
95. Treatment of radiation injury	x				
96. Eustachian tube function in the cat, rabbit and guinea pig	x	x	x		
97. Metabolic response of men to changing skin temperature	x	x	x	x	x
98. The relationship between cardiac output and intra-thoracic pressure	x	x	x	x	
99. Shock in man; clinical studies during injury shock and resuscitation	x	x	x	x	x
100. Changes in muscle after cold acclimatization		x	x	x	x
101. Fat metabolism of cold-exposed and hibernating mammals		x	x		
G — OCEANOGRAPHY					
1. Estuary current profiles	x	x	x	x	
2. Plankton indicators	x	x	x	x	x
3. Oxygen as an oceanographic variable	x	x	x	x	x
4. Marine benthonic organism indicators	x	x	x	x	x
5. Optical properties of inlet and coastal waters	x				
6. Sediments and microtopograph of the continental margin, Maritime Provinces				x	x
7. Surface waves near pack ice		x	x	x	x
8. Sonic scattering layers of biological origin in the sea	x	x	x	x	x
H — PHYSICS					
1. Studies of ionic ferromagnets					x
2. Investigations in aerophysics	x	x	x	x	x
3. X-ray studies on transition elements	x	x	x	x	x
4. The temperature dependence of the D.C. conductivity of dielectrics with long relaxation times			x	x	x
5. Transition in thin liquid films			x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

H — PHYSICS (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
6. Interaction of high intensity electromagnetic radiation (light) and acoustic excitations in matter				x	x
7. Physical properties of crystals containing defects in excited states					x
8. Study of optical properties of solids in the infrared					x
9. Fundamental investigations in electronic physics	x	x	x	x	x
10. Study of solid-vapour equilibria of inorganic semi-conductor materials			x	x	x
11. Effect of microstructural geometry on the ductility of hexagonal metals	x	x	x	x	x
12. Effect of metallurgical variables on properties of electronic materials: superconductors, semiconductors, lasers					x
13. Vibrational lifetimes of CO_2 and N_2O	x				
14. Investigations of positronium	x	x	x		
15. Kinetic studies of the solid state using photo-microscopic techniques	x	x	x		
16. Solid state atomic migration					x
17. Shock wave propagation through solids	x	x			
18. Fundamental studies of photo-conductors	x	x			
19. Properties of solids in high magnetic fields	x	x			
20. Transmission and reflection of sound in fluid-filled conduits	x	x	x		
21. Atomic arrangement and ferro-magnetism in alloys	x	x	x	x	x
22. Infra-red phenomena in solids		x	x	x	x
23. Model studies of reverberation from sea ice					x
24. Thermal properties of superconductors	x	x	x	x	x
25. Optical properties of semiconductors			x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

H — PHYSICS (Cont'd)

Title	Years Project Active 62/63	63/64	64/65	65/66	66/67
26. Dissociation of diatomic molecules in shock waves over a wide temperature range				x	x
27. Slip mechanisms in single crystals			x	x	x
28. McMaster nuclear reactor	x	x	x	x	x
29. Linear accelerator laboratory	x	x			
30. Fabry-perot photoelectric interferential spectrometer					x
31. Drag coefficients of evaporating droplets in a high temperature environment					x
32. Physics of metals in very low temperatures	x	x	x	x	x
33. Thermal properties in helium at low temperatures	x	x	x	x	x
34. Properties of liquid helium	x	x	x	x	x
35. Investigations in aerophysics	x	x	x		
36. Heat transfer from a solid to liquid He II		x	x	x	x
37. Ferromagnetism and anti-ferro-magnetism at low temperature				x	x
38. Injection lasers				x	x
39. Infrared studies of small molecules of planetary interest					x
40. Properties of plasmas			x	x	x

I — SOLID EARTH SCIENCES

Title	62/63	63/64	64/65	65/66	66/67
1. Forces verticales exercées par les glaces en milieu confiné					x
2. Seismic source mechanisms					x
3. Correlation of index and mechanical properties of soils			x	x	x
4. Dynamic response of a muskeg surface					x
5. Consolidation of muskeg	x	x	x	x	x
6. Geology and geophysics of sediments beneath Canadian Atlantic coastal waters	x	x	x	x	x
7. Heat budget analysis of Jones Sound	x	x	x	x	

TABLE 1 — List of University Research Grants (Cont'd)

I — SOLID EARTH SCIENCES (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
8. Sub-Arctic sand dunes at Lake Athabasca	x	x			
9. A heavy mineral study on the regional distribution and provenance of beach sediments of Nova Scotia	x				
10. Investigation of dynamic elastic constants and strengths of brittle rocks		x	x	x	x
11. Seismic wave propagation in underwater layered media with non-sharp boundaries					x
12. Seismological investigation of the earth's crust in Western Canada	x	x	x	x	x
13. Natural electro-magnetic background	x	x	x	x	x
14. Geomagnetic micropulsations and magneto-telluric modelling				x	x
15. Submarine geology and geophysics of Barrow Strait			x	x	x
16. Behaviour of soils under blast and similar loads		x	x	x	x
17. Magneto-telluric modelling	x	x	x		
18. Investigation of surface roughness of muskeg				x	x
19. Arctic bibliography	x	x	x	x	
20. Electrical and thermal properties of the upper mantle of the earth	x	x	x	x	x
J — PSYCHOLOGY					
1. Psychological criteria of optimal mental and psychomotor performance	x	x	x	x	x
2. Parameters affecting vernier acuity				x	x
3. The effects of terrain upon perceived size and distance			x	x	x
4. The effect of repetition and individual differences in short-term memory				x	x
5. Effects of variations in response strength on recognition thresholds	x	x	x	x	
6. The efficiency of subliminal stimulation influencing the acquisition of information	x	x	x	x	

TABLE 1 — List of University Research Grants (Cont'd)

J — PSYCHOLOGY (Cont'd)

	Years Project Active				
Title	*62/63*	*63/64*	*64/65*	*65/66*	*66/67*
7. Brain function and perception	x	x	x	x	
8. Verbal mediation, operator-control-display interaction and perceptual motor performance	x	x	x	x	
9. Interstimulus interval and simple reaction time	x	x	x	x	
10. Verbal conditioning and individual judgment		x	x	x	
11. Parametric studies of sensory preconditioning in humans		x	x	x	x
12. Effects of verbal pretraining on transfer to a discriminative motor task		x	x	x	x
13. Decision processes in individual and group problem solving			x	x	
14. Study of personnel factors in isolated northern posts	x	x	x	x	
15. Coding in perception and immediate memory			x	x	x
16. Behavioural and perceptual re-adaptation to a diminutive visual world			x	x	x
17. Effect of implicit context on the perception of size and distance					x
18. Pitch discrimination and aural fatigue	x				
19. Locus of temporary work decrement in perceptual-motor performance	x	x	x	x	
20. The generality of courage				x	x
21. "Background" sensory cues and performance	x	x	x	x	x
22. Decay processes in short-term memory			x	x	x
23. Training the absolute judgment of pitch					x
24. Visual discrimination as a function of size of response set and repeated experience					x
25. Stimulus determinants of attention in the perceptual learning process					x
26. Orientation problems with unorthodox imagery in air space systems		x	x	x	x

TABLE 1 — List of University Research Grants (Cont'd)

J — PSYCHOLOGY (Cont'd)

Title	62/63	63/64	64/65	65/66	66/67
	Years Project Active				
27. Serial order and 'holding' in perception	x	x	x	x	x
28. Learning properties of randomly connected nets of electronic neurons	x	x	x	x	x
29. Investigation of stereoscopic vision under intermittent stimulation	x	x	x	x	x

K — SOCIOLOGY

Title	62/63	63/64	64/65	65/66	66/67
1. Modification of social behavior through observational learning		x	x	x	x
2. Secondary status characteristics and the organization of task groups					x
3. The social organization of applied science	x	x	x	x	
4. Ascendent-submissive behavior in pairs of human subjects as a function of their "emotional responsiveness" and intelligence	x	x			
5. Study of small group behaviour	x				
6. Individual differences in social judgments			x	x	x
7. Research on the dynamics of human pilots					x
8. Cooperation, competition, and the structure of social interaction		x	x	x	x
9. The development and evaluation of procedures for the investigation of goal seeking processes with special reference to optimization and adaptation		x	x	x	x
10. Psychological and social aspects of bilingual skill; measurement of linguistic dominance	x	x	x	x	x

TABLE 2 — List of Defence Industrial Research Grants*

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
1. Wing Augmentor Research	x	x	x	x	x
2. Advanced STOL Turbofan Powered Transports Utilising BLC and Vectored Thrust				x	x
3. VTOL Fan-in Fuselage Research Program				x	x
4. VTOL External Augmentor Research Program				x	x
5. Mechanical High Lift Systems (Phase I)					x
6. Lateral Handling Qualities of Small Aircraft					x
7. Gust Response of STOL Aircraft					x
8. Slipstream Interference with Four Propeller/Wing Configurations					x
9. Mathematical Applications in Aerodynamic Design and Analysis Procedures					x
10. Signal Processing	x	x	x	x	x
11. Submicron Dielectric Films		x	x	x	x
12. Ferrite Research			x	x	x
13. Electromagnetic Digital Displays and AC/DC Transducing Devices			x	x	x
14. Polycrystalline Ceramics for Substrates			x	x	x
15. Use of Iron Oxides in the Preparation of Magnetic Oxides			x	x	x
16. Electronic Improvement and Processing of TV Generated Reconnaissance and Weather Pictures			x	x	x
17. Injection Luminescence			x	x	x
18. Research on Silicon Integrated Circuits			x	x	x
19. The Physical Properties of Selenium, Tellurium and their Semi-conducting Compounds			x	x	x
20. A Study of Visual Simulation Problems in Flying Training Systems			x	x	x

* All the DIR Grants belong in the "Engineering and Technology" discipline.

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	62/63	63/64	64/65	65/66	66/67
	Years Project Active				
21. Thin R.F. Magnetic Films			x	x	x
22. Electrolytic Integration				x	x
23. Signal Processing in Advanced Sonar Systems				x	x
24. A Continuing Magnetic Anomaly Detection Research Program (MAD)				x	x
25. Radar Techniques				x	x
26. Support of Advanced Semiconductor Devices and Circuits				x	x
27. Advanced Magnetic Sensing Devices				x	x
28. The Application of Semiconductor Diode Light Emitters				x	x
29. Underwater Seismic Research				x	x
30. Tantalum/Tantalum Oxide System for HF Electrolytic Capacitors				x	x
31. Applied Research on Photodevices					x
32. Advanced Microwave Circuitry					x
33. Electroless Deposition of Resistive Metal Films					x
34. Non-Linear Resistive Thin Films					x
35. Thin Film UHF Voltage Tunable Circuits					x
36. Digital Computation for Simulators					x
37. Microelectronic Circuit Techniques Applicable to Avionics and Military Equipment Design					x
38. Materials for Variable Resistors					x
39. Solid State and Thin Film Processes and Devices					x
40. Pattern Recognition Systems					x
41. Electroluminescence Switching Problems					x
42. Semiconductor and Dielectric Materials					x
43. Preparation and Properties of Ferrimagnetic					x
44. Silicon Carbide Devices					x
45. Silicon Carbide Materials					x

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
46. Welding Research on High Strength Steels	x	x			
47. Improved Magnesium Die-Casting Alloys	x	x	x		
48. Zinc Die Casting Alloys with High Resistance to Low Temperature Impact	x	x	x	x	
49. Turbine Blade Coating Research		x	x	x	x
50. Improved Fabrication Methods for Lightweight High Strength Pressure Vessels			x	x	
51. High Purity Iron Powder by the Ferrous Chloride Technique and Application and Fabrication of this Powder			x	x	x
52. Superior Die Material for Die Casting				x	x
53. Automated Structural Analysis Procedure (Astra)					x
54. High Strength Steels for Servo Mechanisms					x
55. Power Spectral Density Techniques in Structural Analysis					x
56. Evaluation of Titanium Welding and Machining Techniques					x
57. Dispersion Strengthened Nickel-Chromium Alloy Powder Research					x
58. Analysis of Aircraft Vibration Modes					x
59. Machinability of Stainless Steels					x
60. Thin Gauge Diffusely Stiffened Composite Structural Components					x
61. An Optimum Panel Analysis Procedure					x
62. Centrifugal Compressor Research	x	x	x	x	x
63. Radial Turbine Research	x	x	x	x	x
64. Combustion Research Program		x	x	x	x
65. Axial/Centrifugal Compressor Research		x	x	x	x
66. Silver Chloride/Magnesium Systems		x	x	x	x
67. High Frequency Coupling System Research			x	x	x

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	Years Project Active				
	62/63	63/64	64/65	65/66	66/67
68. Fluid State Logic Control System			x	x	x
69. Fuel Cell Research			x	x	x
70. Fuel Cell Power Supply for Oceanographic Buoy Application				x	x
71. Mechanical Research into High Rotating Speed Radial Flow Components				x	x
72. Anodic Oxidation of Hydrazine					x
73. A Cooled Radial Turbine Research Program					x
74. Optical Thin Film Technology				x	x
75. Low Speed-High Torque Hydraulic Motors					x
76. Recirculating Ball and Acme Thread Actuators					x
77. Compact Gearboxes					x
78. Gas Bearing Technology					x
79. Storable Tubular Extendible Members (STEMs)					x
80. Electro-optic Crystals for Display Systems				x	x
81. Remote Vapour Detection-Correlation Spectrometer					x
82. Dispersion Strengthening of Nickel-Chromium Ternary and Higher Alloys				x	x
83. STOL Aircraft Research	x	x	x	x	x
84. Low Drag/High Lift Technique		x	x		
85. A Recirculating Ground Effect Machine with Flexible Trunks		x	x	x	x
86. Interference Drag of Cruciform Wing-Body-Nacelle Configurations				x	x
87. STOL Operations				x	x
88. Advanced Turboprop Powered Transports				x	x
89. Study of an Electron Beam Type Mixer	x	x	x	x	
90. Study of Semiconductor Materials for Solid State Devices	x	x	x		
91. Microwave Properties of Plasmas	x	x	x		

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
92. Photoconductive Cells	x	x	x		
93. Intermetallic Compounds	x	x	x	x	
94. Thin Film Circuit Techniques	x	x	x		
95. Electroluminescence for Display Systems	x	x	x		
96. Study of Radio Frequency Suppression Filters	x	x	x		
97. Coded Data Processing	x	x	x	x	
98. Micro Connections for Micro-miniature Circuits	x	x	x		
99. Prevention of Errors in Data Transmission Systems	x	x	x	x	x
100. Cryogenic Research Program	x	x	x	x	
101. Feasibility Study of an Electrolytic Integrator		x			
102. Magnetic Anomaly Detection System (MAD)	x	x	x		
103. Solid State Research in Support of Satellite Telemetry	x	x	x	x	x
104. Non-linear Active Devices	x	x	x	x	
105. Thermoelectric Cooling	x	x	x	x	
106. Properties of ADP & KDP Crystals		x	x	x	x
107. Application of Digital Computation to Flight and Tactical Simulators	x	x	x	x	
108. Research Support in the Field of Laser Applications		x	x	x	
109. Applied Research on Inertial Navigation Devices		x	x	x	x
110. Ionospheric Propagation Studies		x	x	x	
111. Infrared Spectrometers and Radiometers		x	x	x	x
112. Applied Research on Lasers		x	x	x	
113. Organic Electrolyte Systems			x	x	x
114. Support of Devices for Nuclear Radiation Detection		x	x	x	x
115. Preparation of Electronic Ceramics		x	x	x	x
116. New Visual Simulation Techniques		x	x	x	

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	*Years Project Active* 62/63	63/64	64/65	65/66	66/67
117. Thin Film Resistive and Capacitive Elements		x	x	x	x
118. Silicon Photodevices		x	x	x	x
119. Solid State Materials and Devices			x	x	x
120. Silicon Carbide		x	x	x	x
121. The Application of Ultrasonics to the Diagnosis and Prevention of Decompression Sickness		x	x	x	
122. Advanced Research on Photo-conductive Devices			x	x	
123. Advanced Research on the Special Properties of Gaseous Plasmas and Plasma Lasers			x	x	x
124. Thin Film Active Devices			x	x	x
125. Microelectronic Circuits			x	x	x
126. Ground Speed Sensor			x	x	
127. Digital Computation Techniques Applied to Airborne Navigation Systems			x	x	x
128. Corona Degradation of Plastic Insulation			x	x	x
129. Microelectronic Circuit Techniques Applicable to Avionics and Military Equipment Design			x	x	x
130. Extended Range Thin Film Microcircuitry			x	x	x
131. Electroluminescence and its Applications			x	x	x
132. Magnetic Encoders			x	x	x
133. Spread Spectrum Techniques				x	x
134. Semiconductor Transducers				x	x
135. Myoelectric Devices				x	x
136. Thin Film Techniques				x	x
137. Thermoelectric Coolers				x	x
138. Metallic Halide Dissociation	x	x	x	x	x
139. Dispersion Strengthening and Flame Spraying with Powder Metals	x	x	x	x	x
140. Production Methods for Strategic Ferro-Alloys and Refractory Metals	x	x	x		

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
141. Crack Propagation in Panels and Aircraft Structures	x	x	x	x	
142. Effects of Uranium in Aircraft Quality Steels	x	x	x		
143. Submerged Arc Welding Titanium Sheet	x	x	x		
144. Corrosion Resistance of High Strength Steel Sprayed with Aluminum	x	x	x		
145. Chemical Milling of Aluminum Alloys		x	x		
146. Novel Field-Curing System for Epoxy Resins		x	x	x	x
147. Static and Fatigue Strength of Glass Reinforced Plastic Components		x	x	x	
148. Feasibility of Low Pressure Die Casting of Magnesium			x	x	x
149. V/STOL Structural Research				x	x
150. STOL Undercarriage Research				x	x
151. Annular Combustion Chamber Research	x	x	x		
152. Free Piston Engine Research		x	x	x	x
153. Turbofan, Turboprop Study		x	x	x	
154. Cryogenic Research Program		x	x	x	x
155. Alkaline Primary Systems		x	x	x	x
156. Advanced Alternating Current Generator Techniques			x	x	x
157. Turbine Braking			x	x	x
158. Light Weight Regenerator Research			x	x	
159. Heat Exchanger Research			x	x	x
160. Alkaline Manganese Dioxide Systems			x	x	x
161. Wear and Friction	x	x	x	x	x
162. Hydraulic Cylinders		x	x	x	x
163. Vertical Gyro Attitude Reference		x	x	x	
164. Wear and Friction			x	x	

TABLE 2 — List of Defence Industrial Research Grants (Cont'd)

Title	62/63	63/64	64/65	65/66	66/67
		Years Project Active			
165. Shape Effects in Hypervelocity Impact		x	x	x	x
166. Independent Structure (Space) Crew Escape Concepts			x	x	x

TABLE 3 — List of DRB Intramural Projects

DEFENCE RESEARCH ESTABLISHMENT PACIFIC

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
SUBMARINE DETECTION					
Acoustics Research					
Propagation of sound in the sea under various environmental conditions, with reference to the long range detection of submarines	x	x	x	x	x
Under-ice ambient noise and acoustic propagation and related environmental studies in Canadian Arctic waters	x	x	x	x	x
The effect of surface coatings on drag reduction and boundary layer noise of submerged vehicles	x	x	x	x	x
Under-ice acoustic research in the Beaufort Sea	x				
Electromagnetic Research					
Magnetic anomaly detection of submarines in natural noise	x	x	x	x	x
Long period electromagnetic phenomena	x	x	x	x	x
Propagation of low frequency electromagnetic disturbances	x	x	x		
Study of Wakes					
Creation and detection of wakes in the ocean	x	x	x	x	x
DOCKYARD SERVICES					
Investigation of non-destructive methods of boiler examination					x
Evaluation of ships paints	x	x	x	x	x
Cathodic protection	x	x	x	x	x
Electrolytic water treatment	x	x	x	x	x
Application of plastics to Canadian Forces ships in service				x	x
Fluorescent plastic film sea marker			x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE CHEMICAL, BIOLOGICAL AND RADIATION ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
NUCLEAR DEFENCE					
Radiation chemistry	x	x	x	x	x
Radiation physics	x	x	x	x	x
Ionic physics	x				
Radiac instrumentation	x	x	x	x	x
Protection afforded by clothing materials against thermal radiation	x				
Biological effects of ionizing radiation	x	x	x	x	x
NBC protective clothing and equipment	x	x	x	x	x
BIOLOGICAL DEFENCE					
Immunization studies	x	x	x	x	x
Collection and detection of microorganisms in dilute aerosols	x	x	x	x	x
Rapid identification of microorganisms	x	x	x	x	x
CHEMICAL DEFENCE					
Detection of toxic agents	x	x	x	x	x
Decontamination of toxic agents	x	x	x	x	x
Antidotal drugs for toxic agents	x	x	x	x	x
Production and reconditioning of service masks	x	x	x	x	
Adsorption studies	x				
POWER SOURCES					
Power sources	x	x	x	x	x
Torpedo batteries	x	x	x	x	x
Power supply for sonar transmitter			x	x	x
Electrical equipment evaluation and development	x	x	x	x	x
ENTOMOLOGICAL RESEARCH					
Armed Forces Manual on Pest Control	x	x	x	x	x
Protection against biting flies — insecticide dispensing equipment	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE CHEMICAL, BIOLOGICAL AND RADIATION ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
MISCELLANEOUS					
Spectroscopy	x	x			
Experimental work on rubber and plastic mouldings	x				

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

	Years Project Active				
	62/63	63/64	64/65	65/66	66/67
ANTI SUBMARINE WARFARE					
General					
ASW/service projects unit			x	x	x
High-strength low-weight materials	x	x	x	x	x
Dockyard Laboratory Services to the Canadian Armed Forces	x	x	x	x	x
Accustics					
Explosive echo ranging	x	x			
Low frequency acoustics in Canadian coastal waters	x	x			
Development of transducer materials and designs	x	x	x	x	x
Development of signal processing techniques for improved classification and detection	x	x	x	x	x
Underwater acoustics research for submarine detection		x	x	x	x
Research related to sonar for hydrofoil craft		x	x		x
Hydrodynamics					
Hydrofoil craft	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ESTABLISHMENT TORONTO

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
ENVIRONMENTAL STRESS					
Investigation of the effects of exposure to vibrations various applitudes and frequencies upon auditory perception	x	x	x	x	x
Quantitative determination of the physiological effects of angular and linear acceleration	x	x	x	x	x
Physiological responses produced by exposure to various steady environmental states and to sudden environmental changes	x	x	x	x	x
Studies in oxygen toxicity	x	x	x	x	x
Metabolic effects and interrelations of diet, hormones and environmental temperatures			x	x	x
Physiological effects of high ambient pressure				x	x
Measurement and analysis of subsonic, sonic and ultrasonic vibrations in various working areas	x	x	x	x	x
Treatment and control of accidental and induced hypothermia	x	x	x	x	
The biological effects of high energy pressure vibrations	x				
Endocrine responses to physical stimuli	x				
HUMAN FACTORS					
Factors involved in the learning, transfer and retention of skills	x	x	x	x	x
The effect of various design characteristics of controls on operator performance	x	x	x	x	x
Studies of vigilance	x	x	x	x	x
Investigation of factors involved in the presentation and processing of information	x	x	x	x	x
Human factors engineering of RCN and other ships	x	x	x	x	x
Studies in voice communication	x	x	x	x	x
Problems associated with low speed, low level air navigation	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ESTABLISHMENT TORONTO

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
ENVIRONMENTAL PROTECTION					
Environmental protection and personal equipment	x	x	x	x	x
Physical properties of materials for environmental clothing and personal equipment	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
ROCKETS AND PROPELLANTS					
Solid rocket propellant research and development	x	x	x	x	x
Rocket motor research	x	x	x	x	x
Rocket motor for artillery meteorological data sounding system				x	x
High altitude research vehicle (Black Brant II)	x	x	x	x	x
Propulsion test vehicle (Black Brant I)	x	x	x		
Chemical analysis of explosives propellants and ingredients	x	x	x		
ARMAMENT					
Evaluation of armaments and training devices	x	x	x	x	x
Firing trials — Army	x	x	x	x	x
Firing trials — general	x	x	x	x	x
Technical investigation of ammunition and components	x	x	x	x	x
Miscellaneous armament and explosive investigations	x	x	x	x	x
Shipboard magazines — explosive hazards					x
Coloured smoke generators and marine markers			x	x	x
Basic investigations of the mechanisms of armour penetration				x	x
Bomb spotting charges			x	x	x
Coatings for warheads, mines and projectiles		x	x	x	x
Mechanical properties of material under high strain rates	x	x	x	x	x
Ductile-brittle transition in metals by ultrasonic methods			x	x	x
Weapons systems studies	x	x	x	x	x
Design of modifications to ammunition		x	x	x	x
High explosive sensitivity to shock	x	x	x	x	x
Properties of ceramics and ceramic-metal composites produced by reactive hot pressing				x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

CANADIAN ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
Evaluation of training aids		x	x	x	x
Torpedo warhead testing	x	x	x		
Medium anti-tank weapon system	x	x			
Increased range — 105mm Howitzer	x				
ASW					
Anti-submarine weapon improvement				x	x
Technical investigation and modification of A/S projectiles and associated components				x	x
FHE 400 Hydrofoil weapon system studies			x	x	x
Explosive echo ranging development				x	x
DETECTION AND SURVEILLANCE					
PERISCOPTER elevated viewing system				x	x
Composition of the atmosphere and its radiative processes				x	x
Hypersonic physics	x	x	x	x	x
Electro-optical devices				x	x
Military applications of electronic and electro-optical techniques				x	x
Combat intelligence research	x	x	x	x	
Infrared background and transmission measurements at 100,000 feet altitude	x	x	x		
Infrared techniques development	x	x	x		
Battlefield target and background characteristics	x	x	x		
Aerodynamics					
Applied aerodynamics	x	x	x	x	x
Weapons Systems Studies					
Analysis of systems of active defence against ballistic missiles	x	x	x		

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
RADIO COMMUNICATION RESEARCH					
Radio Communications research	x	x	x	x	x
Applications of signal processing to telecommunication systems	x	x	x	x	x
Noise modulation	x	x	x	x	x
Studies of high speed communications techniques	x				
Computer predictions for HF radio propagation	x	x	x	x	x
HF radio propagation prediction service	x	x	x	x	x
Study of an ionospheric high frequency prediction sounder			x	x	x
Millimicrosecond pulse techniques	x	x			
Improvements in maritime communications	x				
Maritime HF communications altitude effect	x				
"Burst Type" long range VHF communications	x				
SATELLITE COMMUNICATIONS RESEARCH					
Multiple access satellite communications				x	x
UPPER ATMOSPHERIC RESEARCH					
Theoretical studies of fundamental physical processes	x	x	x	x	x
Theoretical studies of problems related to the ionosphere	x	x	x	x	x
Radar aurora at UHF and its correlation with other geophysical phenomena	x	x	x	x	x
Upper atmospheric research by rockets	x	x	x	x	x
Studies of the upper atmosphere using radio waves of extra-terrestrial origin	x	x	x	x	x
Studies of the ionosphere using VLF/LF and HF	x	x	x	x	x
Studies of the ionosphere using the Whistler mode of propagation	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT (Cont'd)

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
Synoptic research on the disturbed ionosphere	x	x	x	x	x
The analysis of radio soundings of the ionosphere from satellites	x	x	x	x	x
Measurement and studies of upper atmospheric electron densities and collisional frequencies	x	x	x	x	x
Studies of the upper atmosphere using scatter modes of propagation	x	x	x	x	x
Frequency standard maintenance and frequency control systems	x	x	x		
Ionospheric propagation studies	x	x	x	x	
Missile induced F-layer disturbances	x	x	x		
Ionospheric measurements	x	x	x		
Research on the effects of auroral ionization on UHF propagation	x	x			
Special vertical incidence ionospheric soundings	x	x			
ARCTIC RESEARCH					
Geological, glaciological and climatic studies on the Ellesmere Ice Shelf	x	x	x	x	x
Geophysical studies in the high Arctic	x	x	x	x	x
Sea ice distribution and behavior	x	x	x	x	x
DETECTION RESEARCH					
Microwave propagation		x	x	x	x
Target detection and recognition	x	x	x	x	x
Prince Albert Radar Laboratory experimental program	x	x	x	x	x
Intercept and analysis techniques				x	x
Homer for CF 100	x				
Ground-based monitor equipment	x				
Radar research	x	x	x	x	
Radar signal processing techniques	x	x			
ELECTRONIC RESEARCH					
Automatic techniques in data processing		x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH TELECOMMUNICATIONS ESTABLISHMENT (Cont'd)	*Years Project Active*				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
Microwave and optical properties of materials	x	x	x	x	x
Semiconductor research (circuits)	x	x	x	x	x
Semiconductor devices (components)	x	x	x	x	x
Growth conditions, junction formation and properties of semiconductors	x	x	x	x	x
Transistor digital computation	x	x	x	x	x
Amplification of low energy electronic signals	x				
Intermetallic compound semiconductors	x	x	x	x	x
Application and packaging of electronic components	x	x	x	x	x
SPACE VEHICLE RESEARCH					
Flexible body dynamics					x
Application of scale models to structural dynamics					x
ISIS — International satellites for ionospheric studies	x	x	x	x	x
Instrumentation of a satellite for ionospheric sounding	x	x			

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
SHOCK AND BLAST RESEARCH					
Dynamic loading effects of shock or blast					x
Excavation of 500-ton crater				x	x
Properties of shock waves produced in shock tubes and by free field explosions	x	x	x	x	x
SES participation in Operation Distant Plain					x
Prairie Flat — 500-ton blast trial at SES, 1968					x
Evaluation of the response of emergency measures organization equipment and structures of dynamic loading					x
Evaluation of the response of Canadian Defence Forces equipment and structures to dynamic loading					x
Characteristics of seismic waves from explosive sources					x
Morphology of craters and mechanics of cratering					x
CHEMICAL DEFENCE					
Evaluation of the hazards of toxic agents	x	x	x	x	x
Evaluation of protective measures, including prophylaxis and therapy against toxic agents	x	x	x	x	x
Meteorological studies related to defence	x	x	x	x	x
Research on particulates	x	x	x	x	
BIOLOGICAL DEFENCE					
Laboratory studies of the hazards of bacterial aerosols	x	x	x	x	x
Laboratory studies of the hazards of Ve and Al aerosols	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ANALYSIS ESTABLISHMENT

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
MARITIME STUDIES					
Analysis of maritime operations				x	x
Operational research studies of maritime forces structures				x	x
Studies in maritime operations	x	x	x	x	x
Maritime air defence studies				x	x
Operational research studies of maritime weapons systems				x	x
Analysis of Marlant Exercises	x	x	x	x	x
Analysis of contacts	x	x	x	x	x
Studies of maritime and transport operations	x	x	x	x	
Evaluation of naval weapon and detection systems	x	x	x	x	
LAND FORCE STUDIES					
Methodology of land/air war gaming	x	x	x	x	x
Participation in land force exercises and summer concentrations			x	x	x
Studies of strategically mobile tactical forces				x	x
Land force combat intelligence studies				x	x
Terrain and intervisibility analysis			x	x	x
Investigations of photographic interpretation				x	x
Assistance in planning field trials and experiments				x	x
A study of cost-effectiveness of weapons systems				x	x
Requirements for aids to amphibians			x	x	x
Studies of land operations in limited visibility			x	x	x
Development of operational models and simulations of land operations					x
Investigations of Canadian Land Forces weapons systems	x	x	x	x	x
War games study of future land force combat operations	x	x	x	x	x

TABLE 3 — List of DRB Intramural Projects (Cont'd)

DEFENCE RESEARCH ANALYSIS ESTABLISHMENT (Cont'd)

	Years Project Active				
	62/63	*63/64*	*64/65*	*65/66*	*66/67*
Development and play of training games					x
War gaming brigade operations in northwest Europe					x
Study of operational support and reliability of armoured personnel carrier					x
Computer models of combat operations			x	x	x
Preliminary study of the automation of the CAORE war game			x	x	x
Viewing aids field measurement program			x	x	x
AEROSPACE STUDIES					
Studies of air defence capabilities	x	x	x	x	x
Performance of radars	x	x	x	x	x
North American Defence				x	x
Studies of air defence operations and strike operations	x	x	x	x	x
Systems requirements for tactical air operations			x	x	x
Evaluation of low altitude air defence systems for Canadian Land Forces			x	x	x
Studies of air transport operations				x	x
Weapons systems evaluation	x	x	x	x	
LOGISTIC STUDIES					
Studies of personnel flow				x	x
Survival planning and operations	x	x	x	x	x
Logistics studies			x	x	x
Analysis of strategic transport for mobile tactical forces					x
Mathematical analysis of military formations effectiveness in relation to cost in manpower and equipment	x				

APPENDIX A — ANNEX IX

CASE HISTORIES OF SOME SELECTED PROJECTS

INTRODUCTION

1. The case histories which follow are presented as examples of projects carried out by the Board's establishments that have produced significant results within the past five years. Examples of the results of DRB's extramural projects have been described in earlier annexes.

2. There are many definitions of "basic research", "applied research" and "development" and, in general, they depend on the point of view of the author. The definitions used within the Department of National Defence reflect the mission-oriented point of view and are as follows:

(a) Basic Research is research carried out to increase the accumulated, objective, and systematic knowledge of the inherent properties of matter, space, energy, natural phenomena and biosystems and their interactions. There are two prime motivations for doing basic research. One is composed of curiosity and personal tastes; the other is a serious deficiency in existing knowledge which is recognized as being a real or potential barrier to scientific understanding and technological advances. When pursued for the latter reason it is termed *"objective basic research"* and, in the defence context, the knowledge deficiency must have substantial defence implications to qualify the research as objective basic research.

(b) Applied Research — Includes all effort *concerned with the application of knowledge, materials and/or techniques* to the solution of specific military problems short of development activity. It may involve studies, investigations and the construction of breadboard hardware. The dominant characteristic of this category of effort is that it is directed toward identifying and evaluating the feasibility and practicability of new concepts, techniques or military materiel. The effort may lead to the formulation of OEOs* and OERs*.

* OEO - Operational Equipment Objective

OER = Operational Equipment Requirement

(c) Preliminary Development — Includes systems analysis, feasibility studies, trade-off studies and projects which require the development or use of hardware for technical evaluation or operational test as opposed to design and engineering of hardware for eventual military use. This category of effort will usually be undertaken in response to an OEO and be aimed at the formulation of an OER.

(d) Engineering Development — Includes all projects which require engineering, test and evaluation of systems, sub-systems or equipment for military use but for which production and deployment has not been approved. This category of effort will be conducted in response to an OER.

(e) Operational Systems Development — Includes research and development effort directed toward the acquisition of systems, sub-systems or equipment that have been approved for production and deployment. All activities in this category will be in support of procurement activity.

3. The examples are classified in categories according to these definitions.

EXAMPLES IN THE CATEGORY OF OBJECTIVE BASIC RESEARCH

4. Ocean Acoustics — While passive sound ranging for the detection of submarines had its genesis in World War I, the present method is an active one — a sound signal is generated in the water, and from the resultant echo, the direction and range of the submarine is deduced (SONAR). For the last several decades, our knowledge of how sound behaves in the ocean has not been adequate to meet the needs of the technical officers in the Canadian Forces and the industrial engineers who were concerned with the provision of improved sonar equipment. Consequently when the main burden of developing the Variable Depth Sonar had passed from the Defence Research Establishment Atlantic (DREA) to the Royal Canadian Navy, a decision was taken to spend more effort on investigating the basic phenomena involved.

5. An examination of the US, UK, and Canadian R&D programs indicated that there were three different but closely related possibilities for large

gains in sonar performance, that two of these three were the subjects of large projects in the US or UK and that the third, which was receiving little attention, seemed rather suitable for the approach DRB thought necessary. During this examination the maritime component of the RCAF made a specific request to DREA for some research related to echo ranging using explosives which, it was recognized, would serve as a good first stage of the research program required.

6. DREA then embarked on a research program to use the Reliable Acoustic Path (RAP) (the very deep parts of the ocean) which was a balanced mixture of basic investigation of the acoustic characteristics of the ocean and applied experiments on the detection of submarines. Explosives were used as sources of sound for the research, which meant that the early experiments should yield the scientific information requested by the RCAF. The scientists assigned were involved in both parts of the program so that the "applied" purpose for which the basic work was required should not be forgotten.

7. The equipment required for the RAP research had to be placed very deep in the ocean and it was, therefore, new in concept and very large and heavy. While it was being designed and built, basic research proceeded for some time at shallow depth with fairly simple experiments. DREA scientists were able to separate and measure quantitatively many of the phenomena of ocean acoustics which affect the sonar process. As a result, many of the RCAF questions were answered and others were more sharply defined. Some of the latter are the objectives of DREA projects now in progress.

8. Also, because of the basic investigations, it was possible to predict echo ranging performance and to design more efficient "applied" experiments to check these predictions. Further, since the predictions proved to be reasonably accurate, only a relatively few applied experiments were required to demonstrate the acoustic feasibility of the RAP. These "applied" experiments require greater resources than the basic research experiments, but they are necessary both to assist the Canadian Armed Forces in assessing the operational utility of the concept and to point up anomalies which need further research.

9. The feasiblity has been demonstrated, in particular the very high reliability of detection in all but a few of the circumstances examined. Engineering feasibility and cost-effectiveness need, and are receiving, study primarily in other parts of DND.

10. The results of this research have important non-defence implications which follow from the fundamentally basic approach which was taken. It seems likely that some significant features of the ocean can be studied only by acoustic methods. This suggests cooperative experiments between the oceanographic community and the defence-science community. One example only will be cited since it is currently the subject of joint work between DREA and the Marine Ecology Laboratory (MEL) of the Fisheries Research Board.

11. One of the most important sources of difficulty in the use of long range sonar is the interfering background of sound scattered from horizontal layers of biological organisms in the ocean. Marine biologists are interested in these organisms because they form part of the food chain in the sea, parts of which have direct commercial significance. Because DREA and MEL have quite different reasons for being concerned with the distribution and behaviour of these organisms, and because their skills and techniques are different, a joint effort should result not only in increased efficiency but also in a more penetrating research program.

12. Under-ice Natural Noise in the Canadian Arctic — The objective of the research by the Defence Research Establishment Pacific (DREP) in underwater acoustics in the Canadian Arctic is to obtain a better understanding of the basic environment that determines the performance of acoustic detecting and ranging systems in ice-covered waters.

13. During 1963-64, near Ellef Ringnes Island in the Canadian Archipelago measurements were carried out of the natural under-ice noise under static conditions accompanied by sound propagation tests using explosives. The results from this series of experiments and others which were carried out during the periods in which access to the area was possible, indicated that

the noise producing mechanisms as a result of ice cracking were induced by two basic environmental phenomena, the first being air temperature changes and the second wind speed.

14. Analysis of these initial results indicated the desirability of recording the natural under-ice noise on a year round basis. Consequently a recoverable instrument package was designed by the laboratory and five units were moored in various locations at various depths in the Archipelago. These units are designed to record Arctic environmental acoustics automatically, on an hourly basis, over a full year period. These units were moored from the CCGS *Labrador* in August 1967 and are being recovered during August/September 1968. The recovery operation was also carried out from the CCGS *Labrador*, which carried the PISCES, a commercially developed, deep submersible midget submarine, together with Canadian and American scientific groups cognizant with Arctic scientific problems.

15. Most of the available acoustic information from the waters of the Canadian Archipelago results from measurements made by the Defence Research Establishment Pacific. Analysis of the digital recordings from the recoverable instrument packages together with the collation of the data gathered by the other scientific representatives will yield further valuable basic oceanographic and acoustic research information on the Arctic environment.

16. The Formation of Craters by Explosions — This work started out as applied research, but has resulted in a first class contribution to the basic science of the subject.

17. In the early nineteen fifties, DRB was anxious to develop a capability in the field of nuclear weapons effects, so that it could give competent advice to the Minister of National Defence and the Canadian Armed Forces. But of course Canada had no nuclear weapons, and the law of the United States precluded Canadian scientists from taking part in US nuclear tests. At the same time, the United Kingdom was short of scientists for its rapidly expanding atomic weapons research. Accordingly, DRB scientists helped to make measurements of thermal radiation, shock and blast pressures and analysis

of fallout at the early British nuclear weapons test series. In doing so, they acquired know-how of nuclear weapons effects without gaining any knowledge of nuclear weapons technology.

18. By 1957, such participation was clearly inconsistent with developing Canadian foreign policy. It was desirable to keep the capability in being, and the experience gained had disclosed that all the phenomena connected with explosions were not clearly understood. Some excellent work had been done with high explosives in Britain, but in that crowded island it was difficult to explode more than one ton of TNT. The British suggested that Canada could make a contribution by working in the multi-ton range since we had isolated test facilities. Accordingly a shock and blast program was started at the Defence Research Establishment Suffield (DRES), to investigate the basic phenomenology of explosions and to gain knowledge of the forces exerted by an explosion on model shapes and real equipment, including the craters formed by an explosion so that realistic advice could be given to Canadian Armed Forces and Civil Defence. Techniques had to be perfected, and an explosion of 5 tons in 1959 was followed by 20 tons in 1960, 100 tons in 1961 and 500 tons in 1964.

19. Knowledge of the kind of craters to be expected from nuclear explosions on land was based on those formed by nuclear tests at the Nevada Test Site in USA. As early as the 20 ton explosion in 1960 it became evident that the craters being formed by test explosions at Defence Research Establishment Suffield differed markedly from those at the Nevada Test Site because they were wider and shallower. Several years later, it seems probable that the Suffield craters more likely represent what would happen in most areas of the world than the Nevada ones do. The Nevada geology is fairly rare.

20. At the 1961 explosion, but more particularly at the 500 ton explosion in 1964, extensive instrumentation was introduced. Along with the most accurate surveying before and after, coloured columns of sand and identifiable capsules placed in the crater area showed the movement of the various strata in the earth, while seismometers measured the forces in operation beyond. The crater from the 1964 explosion was of the greatest interest to geologists, geophysicists and astronomers. It resembled very strongly craters observed

on the moon (and Mars) and the remains of similar craters on earth. Not only was there a central uplift but the usual crater lip was slumped or depressed, there was radial and circumferential cracking, expulsion of sand and water from great depth, and other interesting geological effects. As a result of 3 years analysis of the extensive information derived from the instrumentations, this project has contributed much original knowledge on the forces at work, and the nature of the formation of impact or explosive craters.

21. This work was successful because:

(a) DRB had available a very large test area within which it was possible to find the relatively small areas required for the experiments.

(b) The staff concerned were competent, and enthusiastic because the problem was basically interesting.

(c) Extensive interchange of information in the US and UK through the Technical Cooperation Program ensured that the proper information was sought, and in the proper way.

(d) Valuable support in the experiments was provided by USA.

22. Ionospheric Research by Satellite — One of the most prominent of DRB's accomplishments is the world-renowned success of the Alouette satellites. These have been outstandingly successful in relation to both scientific results and engineering achievements. Nevertheless many do not realize that the satellite program developed naturally as part of a long-standing research program in a field of defence interest. The defence interest was telecommunications and the roots of the program can be traced back to a request from the Royal Canadian Navy during World War II asking NRC to study the conditions which affect radio transmissions. Studies of ionospheric conditions and their effects on telecommunications began in 1941.

23. Thus, since its inception, DRB has had a long-term research program on the upper atmosphere as an essential foundation for the development, design or improvement of communications systems or circuits in which the upper atmosphere plays some role.

24. Originally all upper atmosphere experiments were conducted from the ground, and obtained information about this region by observing the modificacion of radio waves propagating through it. Observations have been made using waves with frequencies from a few cycles per second to many megacycles. The absorption, reflection, partial reflection, scatter, dispersion and polarization of such waves have all been studied in efforts to deduce the variation of electron density and collision frequency as a function of height, and to understand the terrestrial, interplanetary, and solar physical processes that determine these parameters.

25. Until the space age all observations were necessarily made from the ground, from aircraft, or from balloons. As soon as rockets and satellites were available it was a natural extension of the program to use them as observational platforms.

26. The scientific reason for launching the Alouette Satellite (1962) and its successor, Alouette II (1965) was to obtain information about the ionosphere, that region from 50 to 600 km above the earth's surface where there are layers of ionized gases (plasmas) on which nearly all military and many civil communications depend. The ionosphere had previously been investigated only from below.

27. The data from the two Alouettes has greatly advanced the knowledge and understanding of the top part of the ionosphere (scientists in many lands have used the Alouette data for scientific papers). Although the complexity of the structure of the ionosphere is such that analysis is far from complete, the gross structure is now reasonably well established, but many other phenomena have been uncovered by analysis of these records.

28. A new technique has been discovered for the measurement of exceedingly low electron densities by making use of the beat frequency between two plasma resonances excited by the sounder transmitter. The technique has made possible the accurate measurement of the lowest electron densities encountered at Alouette heights, about 8 electrons per cubic centimeter. This Alouette technique is now being used to calibrate measurements and enhance the accuracy of other research involving the study of low electron densities.

29. Guidance of high-frequency (HF) radio waves by the earth's magnetic field along ionization "ducts" has been dramatically demonstrated by some of the Alouette records. These show that the radio waves may follow the magnetic field lines for some 10,000 kilometers, reverse direction at high latitudes in the northern and southern hemispheres, and make as many as four "hops" across the equator.

30. Several important plasma effects were first observed by the Alouette satellites. (Ionized gases, such as the ionosphere, are often called "plasmas" to indicate their peculiar properties). The observation of plasma resonances at harmonics of the gyrofrequency has permitted a direct check of existing theories of the strength of the earth's magnetic field at great heights.

31. Another newly observed plasma phenomenon has been called "remote resonance", because the resonance effect occurs at a considerable distance from the satellite. Discovery of this resonance has stimulated laboratory research into a new aspect of the nature of plasmas. One of the most useful consequences of the observation of these plasma effects has been the uncovering of a band of very low frequency (VLF) radio noise from which a great deal has been deduced about the composition and temperature of the upper atmosphere. For example, atomic oxygen is the most abundant ion at 1000 km over the polar regions, whereas hydrogen is the predominant ion near the equator. It has been found that the temperature of the plasma is about 1300°C in the polar region, at 1000 km above the earth.

32. The radio noise experiments on Alouette made the first comprehensive measurements of extra-terrestrial (i.e. "cosmic") radio noise levels for frequencies below five megacycles/sec., measurements which cannot be made on the ground due to the blanketing effect of the ionosphere. The noise levels were found to differ by almost an order of magnitude from a few previous values obtained in other ways. This experiment was also the first to measure, at these frequencies, bursts of radio wave energy that originated on the sun and has made possible the first deductions of properties of the solar corona at distances of 5-20 solar radii from the sun (still impossible to obtain from rocket-launched probes).

33. The radio noise experiments have also provided new and significant data on radio noise levels generated terrestrially; i.e., noise originating in the ionosphere. The mechanisms whereby this noise — which may be very intense between 200 kilocycles and 1 megacycle/sec — is generated, are now being studied and are expected to improve knowledge of energetic processes in plasmas. Four distinctive bands of noise, corresponding to four different plasma generation processes, have been identified.

34. The success of this research program, depended of course, on the success of the satellite project. This was successful because:

(a) It was an extension into a new area of a technology in which the Defence Research Telecommunications Establishment had long experience.

(b) It was a highly imaginative program which appealed to the staff involved. Consequently the difficulties — and there were many — became challenges to be overcome.

(c) The initial project — Alouette I — was controlled all the way from the basic research to the final engineering development and operational control, by the one organization, Defence Research Telecommunications Establishment. The importance of this cannot be stressed too highly.

(d) The staff on both research and engineering aspects were highly competent.

(e) Responsibilities were clearly assigned, internal communications were good, problems were identified, alternatives discussed and timely decisions agreed.

35. Hypersonic Physics — This is the age of high speed flight. Military aircraft which fly at several times the speed of sound are now considered conventional and supersonic commercial transports are now under design or construction. Satellites and space probes re-enter the earth's atmosphere at hypersonic velocities of the order of 18,000 miles per hour as will intercontinental ballistic missiles if ever used. New defensive missiles must fly in the atmosphere at hypersonic speeds.

36. Meteorites, as is well known, tend to burn up during their flight through the earth's atmosphere, converting their vast energy of motion into heat and ionization in a long luminous trail. Reentry warheads will behave similarly and some aspects of research against ballistic missiles are aimed at determining if their trails can be used to detect and locate them. Canadian Armament Research and Development Establishment (CARDE) has developed and now operates one of the best equipped reentry simulation laboratories in the western world for basic research on the characteristics of missile trails or wakes.

37. High altitude is simulated by a pressure vessel or range which can be evacuated to as low a pressure as required. Range 5 at CARDE is 10 ft. in diameter and 400 ft. long. Into these ranges are projected models fired by "gas guns", which achieve very high velocities, the development of which was a pioneering effort in CARDE. For instance, a 4 inch bore gun launches a 2.7 lb projectile at velocities up to 16,500 feet per second. Others give velocities up to 25,000 feet per second. The combination of gun and pressure vessel is called a hypersonic range.

38. The projectile flies down along the axis of the tank and the measuring equipment can be located along the tank either on the inside or the outside. Observations can thus be made very close to the body in flight and although the models are considerably scaled-down in size, the proximity of the measuring instrument more than compensates for this. For combinations of velocity and air pressure in the tank, simulation of conditions at any point of an actual reentry trajectory can be achieved.

39. All this results in the emission of light, and analysis of this light, which requires very elaborate instrumentation gives a faithful representation of the processes occurring around the model. The processes going on in the shock front also result in radiations in the radio-frequency range, so that radio and radar measurements are also made (CARDE was again a pioneer here). These analyses are all made in relation to the position and time of flight of the model. This research contributes much to understanding what happens ahead of an object re-entering the atmosphere.

40. In 1965, interest shifted to what happens behind the object — that is, the wake, which is the part which is most likely to be detected by radar. Response to radar depends on how long the free electrons in the wake will last, and this cannot be assessed until the flow of air into the wake, and the subsequent behaviour of the wake is understood.

41. The hypersonic ballistic range is perhaps the best facility for investigations of the wake behind projectiles in free-flight, since it allows the wake to be examined from close to the model to very far behind it. To get good measurements, large projectiles must be launched. The ability to use 2.7 inch diameter projectiles has been a crucial element in the success of the wake experiments undertaken by CARDE.

42. Again, very elaborate instrumentation was developed to measure (a) the wake velocity (b) the mass density across the wake (c) temperatures (d) electron densities. The results obtained are of great interest in the acquisition by radars of incoming ballistic missiles. There has until now been no effort of comparable importance and breadth on hypersonic wake research at any single US establishment.

43. This program is considered by experts in the United States as being successful and yielding original and needed results. In assessing why this is so, a few factors immediately appear as having been of great importance. Firstly, CARDE started work very soon after the problems appeared. Canada had few people with training in Aerophysics at that time and the research group in CARDE was formed with scientists from numerous disciplines (nuclear physics, physical chemistry, aerodynamics, etc.). Why then could such an effort be successful? The answer appears to be because, having entered early in the field, the morale was good and the activity was at its peak most of the time. There was no impression of simply following behind the work done in US Establishments or Industry. In some aspects CARDE was leading and could manage to maintain a lead. This was only possible because:

(a) The program has been of long enough duration to allow time for unspecialized scientists to become experts. This takes about 3 years.

(b) The support given to the program has been adequate especially with the additional funding received from the US without however being at a markedly different level from what Canada can in general deploy for research programs.

EXAMPLES IN THE CATEGORY OF APPLIED RESEARCH

44. Hydrofoil Craft for Maritime Defence — The hydrofoil principle offers one of the few potential answers to the problem of increasing the speed of surface ships in rough water. Coupled with a threat of submarine speeds exceeding those of conventional surface ships, this was the reason behind DRB's hydrofoil research program. Between 1952 and 1958 experiments were conducted with small hydrofoil craft to confirm this promise and to determine the factors involved in designing hydrofoil systems for optimum seakeeping relative to craft size.

45. By 1958, a good general understanding had been gained and a more specific objective was needed to concentrate the effort if the project was to proceed towards development. Defence Research Establishment Atlantic (DREA) formed a special study team of two scientists and two naval officers to answer the question: "Have hydrofoil craft important defence applications? If so, what are they and what characteristics would be required?" Concurrently, the Hydrofoil Group set out to determine what craft characteristics would be technically attainable, assuming a five-year development program.

46. The basic concept which evolved from these studies was to use the stabilizing principle of hydrofoils to produce the smallest possible ship capable of operating a conventional destroyer-escort sonar in the open ocean. Earlier experiments had suggested that the seakeeping ability of a hydrofoil craft in the hullborne condition could be equivalent to that of a conventional ship ten times its displacement. This would mean from 3 to 6 times as many sonars at sea for the same cost, the exact figure depending on the logistic support required. So small a craft would have a maximum hull speed of about 15 knots, which is a good search speed, and interception would be carried out when foilborne, at 50 knots in sea states (SS) up to SS 5. Thus the

anti-submarine hydrofoil concept combined attributes of the destroyer-escort and its helicopter and promised significantly more cost-effectiveness in ASW than any other vehicle.

47. DREA carried out a sketch design concept in sufficient detail to determine the size of craft, power plant, hydrofoil configuration and general hull design required to meet the hypothetical operational requirements to confirm the feasibility of developing such a craft and to estimate its performance. A tripartite (US, UK, Canada) meeting of experts was convened early in 1960 to review these studies critically, and it was concluded that the concept was sufficiently promising to justify a detailed engineering design study by industry.

48. This study was conducted by the DeHavilland Aircraft of Canada Limited working from the DREA concept and with DREA providing part-time advisers. In June 1961, having carried out a comprehensive engineering analysis, DeHavilland concluded that the hydrofoil craft design conceived by DREA and developed by them was feasible.

49. A second phase of studies by DeHavilland then commenced, centred around programs of model experiments to obtain the design data required for the craft. DREA converted its 3-ton "Rx" hydrofoil research craft to carry a ¼-scale model of the hydrofoil system proposed for the 200-ton ship, and worked closely with DeHavilland in developing this design. Specifically, the Rx craft was able to operate in rough water and carry out turning manoeuvers which are not possible with the conventional type of model test facilities.

50. In 1963, the RCN contracted with DeHavilland for the design and construction of a full-scale prototype ship. A DRB officer served as deputy to the RCN program manager during the design phase, calling on technical expertise from DREA as required. Model tests continued with the Rx craft to refine the final hydrofoil system design and to confirm the validity of DeHavilland's analog simulation of dynamic behaviour.

51. Throughout this close liaison with DeHavilland, an unofficial but extremely important role of DREA was to inject the marine experience into the thinking of aeronautical engineers and to help interpret RCN requirements at the working level of the designers.

52. Now that the full scale prototype has arrived in Halifax, DREA is participating in the trials program. DREA, DeHavilland and Canadian Forces personnel are combined in an evaluation team with DREA responsible for checking performance against design predictions and gathering data of significance to the design of future hydrofoil ships. DREA is concerned with evaluating the hydrofoil principle, rather than the performance of specific components of the ship.

53. In this regard, the DREA program is unofficially but closely linked with the USN hydrofoil program, which is pursuing the same objective with hydrofoil systems of a radically different type. The complementary nature of the USN and Canadian programs is not accidental, this liaison having been agreed at the Tripartite meeting in 1960. Together, the two USN research ships and the Canadian 200-ton ship cover the spectrum of promising hydrofoil configurations.

54. An Improved System for the Assessment of Submarine Contacts and Tracks — There are many means by which the operations centre at Maritime Command may learn of the presence and movement of submarines. Unfortunately all of these means are fallible. During an anti-submarine exercise, the centre receives a large volume of information, much of which is inaccurate and some of which is completely misleading. In wartime it would almost certainly be worse.

55. In past exercises, too much information has been passed too quickly for proper appraisal. The Commander has been swamped by dozens of reports, many of doubtful validity, but all requiring sifting and study to try to build up a coherent picture of the tracks being followed by submarines which may be attempting to penetrate into or through the area of ocean for which the Commander is responsible.

56. If some means could be found to assess quickly the validity of the many contacts, it would help the hard-pressed Commander to place his limited force of ships and aircraft in the areas most likely to permit them to contact and attack the submarines.

57. In an operational research study the Defence Research Analysis Establishment (DRAE) found that contact information could be rapidly recorded on punched cards which could then be sorted in different ways to provide a quick reference and review technique.

58. By using the results of analyses of previous exercises a means was found to assign a "validity index" to different types of contacts. For example, a visual sighting by an aircraft crew is much more likely to be a bona fide contact on an enemy submarine than a disappearing radar contact. Ship's sonars frequently make contacts which appear to be real but turn out later to be "non-submarine". The problem was to find a reliable measure for how much more credence should be given to one type of contact than to another. The answer was found in a careful analysis of previous exercises from which a "validity index" was obtained.

59. The same type of analysis was applied to assessing the likelihood that a series of contacts might be linked together to form a submarine track. Because of the large number of possible tracks which could arise from a set of contacts, this was a difficult task but a method was found for systematically examining the contacts, eliminating impossible linkages and finding those tracks which *might* be valid. These possible tracks could then be studied by the Commander, using his judgment and knowledge of the situation to arrive at his estimate of which ones were most likely to be the tracks of real submarines.

60. Even when the information on contacts and tracks and its probable validity had been found, it was difficult for the Commander to visualize what it might mean. Operational research provided assistance here by developing a technique for using transparent chart overlays on which

information could be plotted in a convenient form. By assembling overlays in various ways, it became easy for the Commander to see what had happened over a period of time and to make a decision on what to do next.

61. Another problem which had been troublesome in the past was to maintain records in the course of the action which would allow the Commander to review every event up to a particular time along with the current conclusions on the movement and intentions of the submarines. This problem arises every time there is a handover from one Commander to the next. (A "change of watch"). It was solved by developing a procedure which made use of the data cards and chart overlays for quickly recording events and current assessments.

62. The new methods derived from the operational research studies were combined into a system which could be applied by an officer designated as the "Detection Assessment and Threat Appreciation Officer". The system found immediate application at the Maritime Command Headquarters in Halifax and has since been applied with appropriate modifications in several US Navy Operational Control centres. Whenever the system has been applied it has resulted in a significant improvement in the ability of forces to detect penetrations by submarines in exercises. By extension it is anticipated that the same improvement would be achieved in actual operations.

63. This example is illustrative of operational research. The improvements were made in methods and procedures, rather than by design of weapons or new equipment. The means were very simple — use of punched cards and transparent overlays. However, it was necessary to accumulate a great deal of data, to perform extensive statistical analysis, and to perfect the procedures by continued trials.

64. Nickel Cadmium Battery Systems — Applied research at the Defence Chemical, Biological and Radiation Establishment (DCBRE) has led to the development of batteries of exceptional performance for aircraft and satellite applications.

65. Early in 1950, it became evident that existing familiar battery systems were inadequate for military operations in the Canadian environments. The

nickel cadmium battery because of its reported ruggedness, capability for high rate of charge and discharge, and low temperature performance seemed a good candidate for a battery to replace those then used. Basic research studies culminated by the end of the 1950's in new methods of production of electrodes and a good basic understanding of the fundamentals. A number of field trials in army over-snow vehicles and fighter aircraft demonstrated the compatibility of the Ni-Cd battery in the Canadian environment and in military equipments.

66. By the 1960's, the research emphasis was directed towards improving the vented version of the battery to meet the requirements of new high performance aircraft. Towards this end a series of studies directed at determining the effects of various impurities, carbonate, nitrate and other foreign ions, were carried out. The results of these studies are consolidated in the Canadian Military nickel cadmium battery specification CF B70 which is considered by many to be one of the most stringent battery specifications.

67. By 1962, the government approval of DRB's proposal to launch a Canadian satellite (Alouette I) caused DCBRE to concentrate more effort on the sealed version. The problem was to obtain cells that were capable of long life (at least one year) in a hostile environment such as outer space. Every detail of production of components and finished battery had to be examined. In addition, methods of testing to screen out potential weak cells had to be devised. Application of the basic information obtained in the studies on carbonate contamination, impurity ion and methods of charging resulted in cells for Alouette I and later Alouette II which proved to be as rugged and reliable as hoped for. At the present time Alouette I is entering its 7th year of operation and Alouette II its 4th year. It should be noted that most of the work involved was consultative and consisted of translating basic knowledge gained in previous studies into a form understood by production personnel.

68. One of the benefits resulting from the Alouette I problem was the invention and subsequent development of the cadmium hydroxide coulometer as a charge control device. This is essentially a chemical ampere hour meter which gives a voltage signal when the charge removed during discharge has been made up by charging. Studies on this device have resulted in the development of a

number of unique battery power supplies and charger controllers that are beginning to be accepted by the military and civilian user. The coulometer and charger designs have been licensed to a wholly owned Canadian company for exploitation.

69. The success of this applied work is due to the research on fundamentals carried out at DCBRE, for there was virtually no research and development capacity on batteries anywhere in Canadian industry. Of course, this in turn was due to the quality of the staff involved, and their close ties with the military user.

70. Hearing Conservation in the Canadian Armed Forces — With the development of more powerful engines, high intensity noise has become a major problem in both military and civilian operations. In the military environment, noise levels from 85 to 120 dB are common (Home (children asleep) is 40 dB — Private office is 55 dB — Noisy restaurant is 75 dB). Indeed, many personnel are exposed to levels that exceed 140 dB. Exposure may vary from a few seconds to several hours per day, and if beyond safe limits will lead to impairment of hearing.

71. The type and amount of hearing loss suffered by individuals exposed to high intensity noise depends upon their susceptibility to noise, the overall level and nature of the noise, and the number of hazardous exposures and length of time between exposures. Hearing may be damaged if, for example, personnel are exposed to 85 dB for more than four hours each day. The development of hearing loss is gradual, so that the individual is unaware of his condition until it becomes a handicap.

72. The possible effects of exposure to high-intensity noise include, in addition to temporary or permanent losses of hearing, disruption of voice communication, changes in behaviour and in the performance of skilled and unskilled tasks, and mechanical or pathological damage to the body. Such effects may compel changes in operational procedures or may preclude the successful completion of an assignment. Since so many CF personnel are

exposed to relatively high noise levels, a general noise survey and hearing conservation program was initiated by the Surgeon General's Office in collaboration with Defence Research Establishment Toronto (DRET).

73. To obtain the data necessary for the establishment of a proper solution to the problem, an extensive survey of noise levels was carried out by DRET, using conventional sound measurement techniques. Nearly every type of aircraft and helicopter flown by Canadian Armed Forces personnel was included in this survey, as well as shipboard, vehicle and other work-spaces in which noise was a potential hazard. In 1957, the Hearing Conservation Program for the Canadian Armed Forces was introduced, based upon recommendations put forward by DRET. The Program required (1) the designation of potentially noise-hazardous areas (wherever the overall sound levels of the noise exceeded 85 dB), (2) adherence to criteria for the conservation of hearing of individuals working in such areas, (3) the administration of hearing tests, by qualified personnel with calibrated instruments in proper sound environments, to all Canadian Forces personnel at time of enlistment and discharge, and at regular intervals between for all individuals routinely exposed to high-intensity noise, (4) the use of efficient ear protector devices, and (5) an education program to make those individuals exposed to high-intensity noise aware of the risks accompanying such exposures and of the procedures and protective equipment by which these risks can be eliminated.

74. In support of the Hearing Conservation Program, DRET has over a number of years continued to provide information on hearing protection devices, give technical advice to and train Armed Forces personnel in noise measurement techniques and abatement procedures, and present lectures on hearing, noise and hearing conservation to Medical Surgeons and Flight Safety Officers in courses conducted by the Institute of Aviation Medicine.

75. The success of the Armed Forces Hearing Conservation Program has depended on the practicability of the procedures, the enthusiasm of the supervisors, the information given to the personnel involved, and the degree of cooperation between the officers charged with program implementation. Though considerable progress has been made, there remains opportunity for more widespread utilization of the Hearing Conservation Program.

76. Response of Structures to Shock and Blast — The genesis of the program on shock and blast at Defence Research Establishment Suffield (DRES) has been explained in the section under Basic Research dealing with the formation of craters. In the earlier part of this program, there had to be a good deal of Canadian self education, and Canadian effort was devoted to studying the fundamental phenomena of explosions, making sure that what was measured was significant, and to cross-calibrating Canadian instrumentation with British and American instrumentation. During this period, however, the US and UK were both making "target response" measurements at Canadian explosions, and while Canada had expected that 100 ton explosions would be as large as necessary, it was at the urging of the other two countries that this was extended to 500 tons, and explosions of this size were detonated in 1964 and 1968.

77. Having mastered the art of measuring what was required to be measured, DRES recruited engineers for the study of the response of structures to blast, care being taken to integrate as well as possible studies of direct interest to the Canadian Forces, with fundamental studies which would be of more general and long term application. Thus while projects have studied the effect of shock and blast on the large windows on the bridges of naval ships, the particular blast intensity which will trigger anti-personnel mines, the effect of shock and blast on ammunition radiation measuring instruments and radars, the response of fibre glass hatch covers for underground shelters and the structural response of steel framed buildings, the following more fundamental projects also received attention.

78. Examples of these studies are:

(a) Vibrational response of bent structures (such as lattice girder masts) up to and including the onset of plastic deformation including the study of the vibration of typical lattice masts (Navy Masts) under blast loading.

(b) Vibration of constrained polygonal plates.

(c) Forced response of constrained stiffened plates.

(d) The study of nailed laminate and glued laminate panels, and structures such as bunkers based upon these panels. Extension of this study to panels other than flat panels (e.g. hyperbolic paraboloids). Bunkers designed as glued laminate systems are now in use at DRES.

(e) Response into the plastic deformation regime of simply supported steel beams.

79. In addition to the explosives in the field, DRES has, since the earliest part of the program built up facilities for simulating blast in shock tubes and other blast simulators. The largest of these now has a diameter of 6 feet. Blast loading data can be obtained economically in the simulators and finally confirmed in the field experiments, this gives the effects of movement of the equipment by blast which the simulators cannot. This balanced capability enabled DRES to make a considerable contribution in helping the Canadian Forces in Operation SAILOR HAT.

80. Operation SAILOR HAT was a series of multi-ton high explosive trials carried out by the US Defense Department and the US Navy to study the effects of underwater shock and air blast loading on ships. In 1964 the Royal Canadian Navy and the Defence Research Board were invited to participate in two of these trials. The main Canadian objectives were to measure the blast loading on various parts of the ship's superstructure, to measure the response of several regions of the ship's structure and to measure the entry of the blast wave into the interior of the ship.

81. The Canadian ship exposed was HMCS *Fraser*. Prior to the actual trials a series of 200th scale models were made of various cross sections through *Fraser* and the shock interactions with these models were studied in the DRES shock tubes. The results of these tests were used to predict the response of various parts of the ship's structure and determine the location of the gauges used on the trial.

82. Operation SAILOR HAT proved to be a most successful undertaking. Good correlation was obtained between the predicted and the observed values of the

blast loading and subsequent structural response. This trial also served to point up a number of problem areas that should be investigated.

83. Scaled models have been used to obtain similar blast loading data for the new DDH 280 ships. These studies have had a considerable effect on the design of the superstructure. The success of the SAILOR HAT trial and the results of the engineering studies of Canadian Forces equipment led to the initiation of a program whose objectives are:

(a) To provide blast design information which can be applied to DDH 280 and to a lesser extent, to existing ships.

(b) To assess the blast hardness of DDH 280 and existing ships in order that the operational authorities can be advised of the blast characteristics of the various classes in the fleet.

(c) To advance the state-of-the-art in order that future generations of ships will more nearly meet operational requirements and that design criteria will be more readily available to ship designers.

84. Some of the factors responsible for the success of the shock and blast program have been described in Basic Research — Formation of Craters. In the present context, the coordination of effort through the Technical Co-operation Program should be stressed, and the joint financing of cooperative programs by the participating countries.

EXAMPLES IN THE CATEGORY OF "PRELIMINARY DEVELOPMENT"

85. Rocket Propulsion -- The rocket propulsion program at Canadian Armament Research and Development Establishment (CARDE) was started in 1956 with the initial aim of building up a group of experts who could assist in weapon studies with the Armed Services and also to provide a limited production facility for rocket motors in Canada. It was anticipated that early small scale requirements for Canadian produced rockets could be met economically in this manner. Large scale production, if required, would be carried out by industry.

86. In order to meet a Service requirement for immediate firing readiness, solid propellant motors were chosen for study. Although simple enough in principle the solid propellant rocket motor is, in practice, a highly complex device. Extremely severe penalties are paid, in terms of vehicle performance, for quite minor changes in the energy stored per unit weight of the propellant and per unit volume of the motor. The production of thrust can be made to vary as the propellant is consumed so as to satisfy the requirements of the aerodynamicist. This constraint has a profound influence on the internal design of the motor and on the required rate of burning of the propellant.

87. The rocket motor must be as light as possible and yet withstand high pressures, extremely severe transfer of heat from gases at temperatures exceeding 5000°F, and the forces arising from the acceleration of the flight vehicle. Moreover, in modern practice the solid propellant is firmly bonded to the casing structure, consequently any change in ambient temperature produces mechanical forces owing to thermal contraction or expansion; careful design and superior elastic properties are necessary to avoid failure from this cause alone.

88. The need for serviceability in the low temperatures experienced in the Canadian Northland dictated the physical characteristics of suitable propellants. Consequently attention was focussed on propellants based on a solid crystalline oxidizer suspended in a matrix of synthetic rubber called the binder. The rubbery binder burns fiercely in the presence of the oxygen liberated by the oxidizer. An improvement in delivered energy per pound of propellant was realized by incorporating dispersed powdered aluminum as additional fuel.

89. Studies at the Canadian Armament Research and Development Establishment led to the successful development of binders having elastic properties superior to those then in service use. The vital ingredient was a high molecular weight synthetic component (triol) pioneered in Canada. A propellant pilot plant having many advanced features was designed and construction begun at CARDE.

90. In the interests of saving time, suitable off-the-shelf motor casings, 17 inches in diameter and 17 feet long, were purchased from the Bristol Aircraft Company in 1956. Using these casings, a motor containing approximately one ton of propellant was designed. In the spring of 1957 Bristol Aero-Industries of Winnipeg was awarded a contract to build a propulsion test vehicle around this motor. This vehicle was eventually designated the Black Brant I, the first of the very successful series of high altitude sounding vehicles developed in the subsequent Black Brant program. The propellant formulation was finalized in October 1958, the first Black Brant engine was fired statically in February 1959, and in September 1959, the first four Black Brant I vehicles were flight tested successfully at the Fort Churchill Rocket Firing Range. With a 254 pound nose cone the vehicle reached an altitude of 72 miles and impacted at a range of 145 miles.

91. The success of the propulsion test vehicle led to the design of an improved vehicle, the Black Brant IIA. This vehicle was developed by CARDE in conjunction with Canadair Ltd., of Montreal and can deliver 150 lb to an altitude of 125 miles.

92. The fast-paced program carried out at CARDE between 1956 and 1960 led Bristol Aero-Industries Ltd. to propose the development of an extended series of high altitude sounding vehicles. The joint government-industrial programs which followed resulted in the commercial production of the Black Brant Series BBIIA, BBIII, BBIV, AND BBV. Black Brant III is a 10-inch diameter vehicle capable of carrying 40 lb to 110 miles or better; the Black Brant IV, a two-stage vehicle employing the BBIA as its first stage and the BBIII as its upper stage delivers 40 lb to 600 miles; the BBV uses a 17-inch motor with improved performance.

93. During the course of these programs the Propulsion Division at CARDE and its industrial counterpart, now known after several corporate changes as Bristol Aerospace Limited (BAL), developed close cooperation. Tasks were assigned in accordance with local capabilities and adjusted as BAL's facilities were augmented. DRB technology with respect to propellant manufacture was incorporated in the design of the BAL plant. The design and preliminary

testing of all motors except that of Black Brant V was carried out at CARDE. Black Brant V was developed at Winnipeg in conjunction with Aerojet General Corp. of the USA. A number of static firings of BBV were carried out at CARDE to provide an independent assessment of the motor's performance.

94. By mid-1963, CARDE had completed the major portion of its participation in the Black Brant program. The Propulsion Division then began basic studies to upgrade existing technology. New propellants having higher specific energies and improved physical properties were developed. CARDE discovered the destructive phenomenon known as combustion instability was caused by a shock wave, such as is associated with supersonic aircraft, which travels longitudinally inside such motors. Shock waves cause severe disruption of gas flow patterns, rapid fluctuations in the thrust level, excessive pressure and vibration levels and destructively increased rates of heat transfer. Early CARDE knowledge in this area had been applied to the design and testing of the later Black Brant motors. The new data led to widespread recognition of CARDE as an authority in this field and proved to be invaluable in the Meteorological Rocket Program which followed.

95. This program involves the development of two rocket vehicles to be used for obtaining meteorological data at altitudes of 30 km and 70 km respectively. Vehicle costs are of prime importance, the targets being $75 and $350 respectively (less payloads) when mass produced. Moreover, the required characteristics demand the use of high performance rocket motors having propellants with excellent physical properties over a wide temperature range.

96. In April 1965, this program was nominated as a US-Canadian Defence Development Program; Canada accepted the nomination in June 1965. Approval for the participation of CARDE was granted in July 1965. Preliminary studies then began at CARDE while negotiations continued on the Shared Development Program. Contractual support was provided to CARDE beginning in February 1966. Within Canada the program is sponsored by the Department of Industry, the industrial contractor being Bristol Aerospace Limited. On the part of the United States, the US Army Missile Command (USAMICOM) is the responsible agency.

97. CARDE participation in the program includes motor design and development as well as ancillary studies on the behavior of propellant and of motors while combustion is taking place. It was found necessary to change the type of synthetic rubber used in the propellant to one having improved elastic properties. Information provided by the US led to extensive studies on the chemistry and the processing of these new polybutadiene materials. Detailed studies were also required to evaluate the ballistic performance of a variety of propellants based on the new binder material.

98. Static firings in the development phase of the lower range rocket consisted of an evaluation series of 68 heavy-walled motors at CARDE, a transition series of 20 motors with interim flight casings at Bristol Aerospace Limited and 40 motors with flight casings at BAL. CARDE's participation in this phase has now been completed and work is well advanced on the motor of the high range rocket. The designs of the two vehicles are similar and as much information as possible from the one has been used in the other. The main portion of CARDE's contribution will be completed by 1 November 1968.

99. In summary, the roles of CARDE and BAL are complementary in Canadian rocket propulsion development. At CARDE there exists a well demonstrated capability in the development of new binders for propellants, the transferral of laboratory studies to plant scale operation involving up to 3000 lb of propellant, the evaluation of the combustion characteristics of propellants, the complete design of rocket motors, the development of all components except flight-weight casings, and the static testing of rocket motors. This capability is continuously up-dated by studies in polymer chemistry, analytical techniques, chemical engineering, the internal ballistics of rocket motors and fundamental combustion processes.

100. At BAL the emphasis is placed on final flight-weight development, vehicle dynamics, production techniques, vehicle launch and instrumentation, and the testing of motors in their final configuration. The degree of overlap which exists is necessary to both organizations in order to achieve flexibility in programs and to provide valid comparisons of technical evaluations carried out at each establishment.

101. Human Engineering Studies in Ship Bridge Design — In 1961, when a new general purpose frigate was contemplated by the Royal Canadian Navy and preliminary design work commenced, the Director-General, RCN ship design, asked the Defence Research Establishment Toronto (DRET) to provide human engineering design assistance in three main areas. These were the bridge, the operations room and the machinery control room. While the assistance requested in all three areas was given, the following statements relate particularly to bridge design.

102. Ship control is perhaps the key function of a bridge. In conventional ships it is dependent on the relaying of voice orders from the bridge to the engine room or to the wheelhouse situated below decks. This method is unsatisfactory, since it inherently involves delay and risk of communication error. In the preliminary phase, extensive discussions with RCN personnel took place, as a result of which the DRET human engineering group proposed a bridge design that gave the captain or officer conning the ship direct control of engines and helm. In this design, all control, navigation and communications functions essential for the operation of the ship were recognized. In routine situations, operation of the controls by a quartermaster was arranged.

103. The clutter of communications equipment, displays and aids to navigation that protrude from the bulkheads and deck head of the conventional bridge was eliminated in the new design. The bridge equipment was, instead, so arranged that each of the personnel assigned to the bridge could be seated at a console that contained the equipment with which he was concerned. In order to demonstrate this approach to the Navy, an economical full-scale mock-up of the bridge was constructed at DRET. In addition to its value in demonstrating the application of human engineering principles, the mock-up had advantages as a practical research tool, since the merits of different arrangements of equipment and personnel could be explored. Thus, all bridge personnel were seated in the final design, which was accepted by the RCN for the frigate.

104. The USN Marine Engineering Laboratories at Annapolis, Maryland, became extremely interested in the DRET design, and requested that a similar

full-scale mock-up be designed for them at Annapolis. This was done by a member of the DRET staff. Other Navies and civilian shipping companies also showed interest in the concept embodied in the DRET design.

105. Although the RCN frigate program was cancelled, DRB and the RCN sponsored a sea trial in which the actual effectiveness of direct control from the bridge was assessed. A modern destroyer, HMCS *Saskatchewan* was equipped with a small temporary bridge in which both a conventional voice ordered system and a direct control system were installed. Six experienced destroyer captains performed measured manoeuvring tasks about a moving frigate, using both direct and voice-ordered control systems, during trails at sea supervised by DRET observers.

106. The analysis of the performance measurements obtained showed that manoeuvring was, generally speaking, better with the direct control system. Moreover, each test captain expressed preference for the direct system and was ready to use it in the trials after only two or three hours' practice. The potential reduction in training problems was obvious. A responsible officer in the destroyer estimated that up to 21 men could be eliminated, from a ship's company by the installation of a direct control system, representing a long-term saving of massive proportions if the system were introduced in new ships and retrofitted to old.

107. As DRET interest in ship's bridge design became known, the Canadian Coast Guard requested similar assistance in the design of several vessels and in the evaluation of a hovercraft for rescue roles. Aboard a Coast Guard icebreaker, a field trial was conducted to investigate the possible advantages of closed-circuit television to enable bridge personnel to view areas around the ship that were otherwise blind to them, a problem particularly acute in helicopter-carrying destroyers on which the flight deck is invisible from the bridge. This, and a later study aboard a destroyer, demonstrated that the position of the helicopter, the variable depth sonar and the stern of the vessel, could all be made visible to the captain.

108. In all cases, the collaboration of the master and personnel of the ships involved has contributed significantly to the value of these operational studies.

109. Development of Radiation Survey Instruments — As explained elsewhere in the brief, the requirements for radiation instruments for use in a military environment are different from those used in civil nuclear energy projects. In 1958, the Defence Chemical, Biological and Radiation Establishment (DCBRE) was called upon by the Canadian Army to examine the US portable radiation survey meter, having the military designation IM-108, with a view to its adoption by the Canadian Forces for measuring the hazard to troops in the event of nuclear war. This instrument was somewhat unusual in using a device called an "unsaturated ion chamber" as the detector of radiation.

110. An ion chamber is simply a box filled with a gas, usually air, and containing two electrodes with a voltage applied between them. Radiation separates some molecules of the gas into positive and negative ions. Usually the voltage on the chamber is made sufficiently high to attract the ions to the electrodes almost as soon as they are produced, causing an electric current to flow, which is directly proportional to the intensity of radiation. In this case the ion chamber is said to be "saturated" in the sense that increasing the voltage will not cause any significant increase in current. On the other hand, it is possible to arrange the circuit so that the voltage decreases as the radiation intensity is increased, allowing some of the ions to recombine into molecules and not contribute to the current. Such an ion chamber is said to be "unsaturated". With an unsaturated ion chamber a moderate variation in current can represent a very large range of radiation intensities. For troops who are not necessarily skilled at reading instruments this is a great advantage, because it is not necessary to switch ranges so that operation is particularly simple.

111. The IM-108 was found to have a number of deficiencies in relation to military requirements, particularly with regard to cold-weather operation. A program of applied research on the behaviour of unsaturated ion chambers and on the basic properties of ions in air was undertaken. Engineering

investigations were carried out on the characteristics of vacuum tubes used to measure small currents and on the behaviour of batteries and high-value resistors at extremes of temperature. An early result of this work was a redesign of the circuit of the IM-108 which enabled it to meet the military characteristics required by the Canadian Army. This instrument received the designation IM-108B. 4,285 were produced for the Canadian Forces and 10,200 for the Canada Emergency Measures Organization. In the last two years about 19,000 of a version of this instrument, designated the IM-174A, have been produced in Canada for the US Army. The total value of both types was $2,500,000 approximately.

112. The program of applied research, which lasted about 5 years, stimulated the development of several other instruments, all based on the unsaturated ion chamber. Experimental models of a remote area monitor (that is, an instrument designed to have its detector located remotely from the meter and joined by a length of cable) and pocket-sized survey meters intended for use by downed aircrew were built. The remote monitor would operate with its detector at a distance of 1000 ft. as opposed to a distance of 100 ft. for the instrument then in service. A radiation-measuring instrument for use in helicopters and light aircraft was designed to satisfy a requirement of the Quadripartite Treaty countries for aerial radiation surveying. This instrument proved its superiority in competition with others submitted by the US and UK during tests at the Nevada Proving Grounds. It was selected for further development which has now been completed. The military designation is Radiation Detection Set, Airborne, AN/ADR-501. Twenty pre-production instruments have been manufactured to date for user trials. The Canadian Forces and the British Army have announced their intentions to purchase quantities of this instrument.

113. Most recently a three-detector remote monitor was built to a DCBRE design and installed at the Canadian Forces Base, North Bay. The detectors are unsaturated ion chambers, and in fact use components of the AN/ADR-501. The equipment will operate with cable runs of 10,000 feet.

114. The success of these projects was due in the first place to the decision to set up a Radiation Section in the Defence Chemical, Biological Radiation Establishment in 1954, a section which would concentrate on the military aspects of nuclear radiation, and which therefore could not only more independently assess instruments appearing on the market, but redesign them as required. Secondly, very close collaboration with the Military users and the industrial firms capable of producing the instruments. Thirdly, the competence of the staff. The project is also greatly assisted by the fact that a section of the laboratory carries out research on electrical power sources for the Board, and was able to give immediate advice on the power sources necessary to meet military characteristics.

115. Development of Explosive Charges for Submarine Location — The development of a successful munitions item is frequently the outcome of basic and applied research. These related research fields include the chemistry of explosives and propellants, the physics of combustion, detonation, high pressure impact and ballistics, the physical properties of metals, alloys, plastics and ceramics and systems engineering and analysis. This research information is acquired partly through "in house" investigations and partly through information exchange with other countries, primarily the United States and Great Britain. It is the marriage of this basic knowledge with the sciences of design and engineering under the stimulus of new ideas and concepts that produces a new weapon or ammunition.

116. There is as yet no existing single system which by itself is fully effective for detecting and accurately locating submarines under all operational situations. One of the systems being used by the Canadian Armed Forces involves the use of explosive (bomb-like) charges. These, together with sonobuoys, are dropped from aircraft in suspect locations. The sound generated by the explosive charge is reflected from the submarine and detected by the sonobuoy listening device from which this echo is transmitted to the aircraft. By a sound ranging process with pairs of sonobuoys, the location of the submarine may be determined.

117. The original system of sonobuoys and explosive charges was developed by the USA, and was adopted by Canada in the 1950's. However, the explosive

charges were expensive, unreliable and had certain performance limitations. At about the same time the Naval Research Establishment (now Defence Research Establishment Atlantic) began basic studies on the propagation of sound underwater from explosives, with Canadian Armament Research and Development Establishment (CARDE) assistance. CARDE was asked informally by the Air Force to investigate whether improved "operational" underwater explosive charges for the generation of sound could be developed. The initial success of both the CARDE and DREA work led to the development at CARDE of a family of explosive charges.

118. The first of this family of charges was an omnidirectional charge, incorporating nothing new in explosive sound technology, but based on improved "hardware" design and a new fuze concept. This charge has been in service since 1963 and is being produced by industry at a rate of about 20,000 per year to meet Canadian Armed Forces requirements. In addition, over 20,000 have been used by the United Kingdom and over 5,000 by Australia. Five hundred have gone to Germany for trials. Its greater reliability and reduced cost have resulted in a savings of several hundred thousand dollars to the Canadian Armed Forces.

119. It should be pointed out that at first no firm requirements or specifications existed for an improved charge and so it was necessary to make changes to the first design that would otherwise not have been required. However, the development work assisted in the formulation of detailed requirements which were both practical and economical.

120. The charge described above is used during the general location phase of anti-submarine operations. Before the attack phase can begin the submarine's precise course and speed must be known. Another device, with a training version was developed for this purpose. It is fairly complex mechanically since it must float near the sonobuoy and dispense several individual explosive charges in succession at preset intervals. It was developed by industry from a CARDE concept and under CARDE guidance. Preproduction samples are now being evaluated.

121. Another development arose from the fact that, in some situations, particularly in shallow water, explosive signals can be reflected from the ocean bottom or other discontinuities in such a way as to mask the echo from a submarine. Research at DREA, with charges designed by CARDE showed that this masking could be drastically reduced by using, as the sound source, a vertical line of explosive instead of a short thick charge. It also established the useful range of explosive length and weight for such lines. The major design problem to be overcome was to package a 7 ft. length of thin explosive line in a container section 3 inches in diameter and 10 inches long in such a way that the line would open and extend itself vertically when the charge assembly was dropped from the aircraft into the water. Several types of extensible explosive lines were conceived and investigated. One of these has since been adopted by US for a somewhat different application. The CARDE concept has been jointly designed and developed by industry and CARDE anu is being produced in preliminary quantities by Canadian industry.

122. Except for the DREA studies of underwater sound propagation from long thin lines of explosive no new science was involved in the development of this family of explosive charges. The success of the first charge mentioned is due mainly to the cheapness and reliability of the new type of underwater fuze that was conceived and developed for it. That is, successful development was mainly a matter of good ideas and sound engineering skills. The same holds true of the other members of this family of explosives which are just now entering production. It should be noted that the same basic fuze is used on all versions.

CONCLUDING REMARKS

123. Only four examples of preliminary development have been given but it should be noted that some of the best examples of successful preliminary development (and applied research) cannot be described because the information is classified. One should not therefore deduce, from the examples given, the extent to which any particular establishment of the Board is engaged in applied research and preliminary development of direct interest to the Canadian Forces.

APPENDIX 4

SUBMISSION OF THE DEPARTMENT OF NATIONAL DEFENCE

TO THE

SPECIAL COMMITTEE ON SCIENCE POLICY

OF THE

SENATE OF CANADA

PART II – ARMED FORCES ACTIVITIES

Report No. DR 191

October 1968

OTTAWA

68-339

FOREWORD

1. Within the Department of National Defence there are two main agencies that are concerned with aspects of scientific research and development falling within the order of reference of the Special Committee on Science Policy of the Senate of Canada. These are the Defence Research Board and the Chief of Technical Services Branch of the Canadian Armed Forces. Both these organizations are major parts of Canada's scientific and technological community, spending between them on research and development approximately $80 million annually and employing approximately 700 civilian and 200 military professional engineers and scientists.

2. Because of the complexities of identifying the various aspects of R and D in these two large organizations, one primarily civilian and the other primarily military, this submission is presented in two parts:

Part I - Defence Research Board Activities;

Part II - Armed Forces Activities.

As will be found in the detailed presentation, these two agencies work closely together. The format required by the Senate Committee's "Guidelines for Submission of Briefs and Participation in Hearings — Specific guidance for agencies of the Federal Government", has been followed in both cases. Each part has its own Table of Contents, and Summary.

3. A few difficulties existed in providing some of the detailed information requested, partly because of changes accompanying unification of the Armed Forces and partly because scientific activities are not always isolated and recognizable but undertaken within a department whose primary concern is national defence. However, this brief is probably the most detailed and accurate unclassified assessment of *scientific* policies, organization, personnel, expenditures, projects and activities ever made for the Department of National Defence.

4. At the request of the Deputy Minister of National Defence, the Chairman of the Defence Research Board has undertaken to submit the brief with assistance from the Chief of Technical Services.

PART II

ARMED FORCES ACTIVITIES

CONTENTS

LIST OF ANNEXES

SUMMARY OF PART II

This Part of the Submission deals with the activities of the Armed Forces which are concerned with development, testing, evaluation and standardization and which generally fall within the responsibilities of the Technical Services Branch of the Canadian Forces.

The organization of these activities within the department and the machinery for ensuring adequate co-ordination and communication both within the department and with other agencies and departments are described. The nature and value of the diverse international agreements and arrangements are outlined.

The policies which govern the choice of development projects and the machinery used for project formulation and management are described. The importance of retaining a viable defence development activity is discussed. The broad policies governing the use of civilian engineers are stated.

Data are presented on the total costs of the various activities, on the nature of the various programs, on a few selected projects and on personnel.

The activities of the three elements of the organization dealing with testing and standardization are reviewed and detailed information provided.

The following main conclusions are drawn:

(a) The total level of defence development, test and evaluation in Canada amounts to less than 2% of the defence budget but about 10% of the equipment acquisition budget.

(b) Most of the activity does not involve exploitation of novel concepts.

(c) The organizational separation of research from development presents some difficulties but the interface must be viewed in relation to the other interfaces related to engineering, maintenance, supply and requirements definition.

(d) The effective formulation of projects in the overall national interests presents some difficulties.

(e) In spite of the difficulty of selecting and supporting development projects, there are several reasons why it is important to do so.

(f) Most development projects will involve minor improvements and modifications to existing equipment or sub-systems.

(g) Co-operation with our allies in joint development projects is desirable.

(h) Most developments are conducted by industry on contract.

(j) Involvement in the international defence community provides an important means of access to extensive areas of new technology of great value in the non-defence field.

(k) Civilian personnel are used when it is most economical and does not prejudice the maintenance and support of the operational forces.

(m) New procedures for the initiation of equipment acquisition have been introduced with the aim of minimizing slippages and cost escalation.

(n) The test establishments and engineering standardization agencies perform a vitally important function in support of equipment acquisition regardless of the amount of development undertaken.

The following specific recommendations are made:

(1) In any consideration of inter-departmental or inter-agency reorganization, serious consideration should be given to the need to create a suitable climate and improved machinery for initiating and conducting development projects which can serve the overall national interests.

(2) In any consideration of reorganization, the vital importance of retaining military involvement and influence on military equipment projects should be recognized.

(3) The extensive machinery within the defence community for the international exchange of technological information should be recognized as being of vital importance to the overall national technological capability.

PART II — ARMED FORCES ACTIVITIES

INTRODUCTION

1. This part of the Submission deals with those activities of the Department of National Defence of concern to the Committee for which the Canadian Armed Forces are responsible. Most of these activities relate to the acquisition of military equipment and consist mainly of development, engineering, test, evaluation and quality assurance.

2. The activity of main interest to the Committee concerns the development of new equipment and the modification and improvement of existing equipment. Shortly after the integration of the Armed Forces in 1964, the responsibility for the administration of this activity was transferred from the Defence Research Board to the Deputy Minister and the Armed Forces then had full responsibility for development. In fact, however, the division between research and development is quite diffuse and consequently the division of functions between DRB and the Armed Forces is also somewhat diffuse and frequently determined by the need to make the optimum use of the available skills and resources.

3. Certain difficulties exist in providing some of the detailed information because most of the activities of interest to the committee are not isolated in specific organizational entities but are undertaken within the organization whose primary responsibility is the acquisition of equipment. Some of the information on the cost of internal activities and on personnel is therefore unobtainable or of a very approximate nature.

4. There is a substantial amount of activity which falls in the category of testing and standardization. Much of this can be identified in specific units and is somewhat easier to report upon. Since it is mainly in direct support of equipment procurement it is perhaps of less specific interest to the Committee than the more scientific functions of research and development, and it has been treated in a more general way in a separate section of the Submission.

5. The final section of this part of the Submission contains the conclusions and recommendations related to the activities of the Armed Forces.

DEVELOPMENT ACTIVITIES

6. To facilitate a clear understanding of this section it is important that the term "development" should be defined adequately. In the context of defence, an agreed nomenclature has been established. Within the spectrum of research and development activity the terms Basic Research, Applied Research, Preliminary Development, Engineering Development and Operational Systems Development have been defined. These definitions, along with a few others for relevant activities, are reproduced in Annex A. In general, DRB has a primary responsibility for Basic Research and Applied Research and the Armed Forces for Engineering Development and Operational Systems Development. The Armed Forces are also responsible for Preliminary Development but the activity may often be undertaken by DRB.

Organization

7. Within the Department of National Defence, the Chief of Defence Staff (CDS), the Deputy Minister (DM) and the Chairman, Defence Research Board (CDRB) are responsible directly to the Minister (Figure 1). The CDS is responsible for formulating plans and policies to meet Canadian defence commitments, for implementing these plans and policies and for commanding and administering the Armed Forces.

8. The DM is responsible for reviewing the financial aspects of operational policy and for some aspects of personnel and administration. CDRB is responsible for providing scientific support to the Armed Forces and for advising the Minister on all matters concerned with science and technology and research and development.

9. Under the CDS (Figure 2), the Vice Chief of Defence Staff is responsible for operational planning, force development, the formulation of equipment requirements and the determination of program priorities. The Chief of Technical Services (CTS) is responsible for the plans and policies and their

implementation required to meet the materiel needs of the Armed Forces. He is thus responsible for equipment acquisition (including development), maintenance, supply, transportation and construction engineering.

10. To perform these functions, the Technical Services Branch (Figure 3) is divided into three sub-branches. The Deputy Chief Engineering (DCENG) is responsible for matters concerned with the acquisition of new equipment (including development) required to meet the operational needs of the Armed Forces. This officer therefore has the primary responsibility within the Armed Forces for most of the activities which fall within the scope of this review. It should, however, be recognized that the primary activities of this sub-branch do not involve development but are concerned with the management of equipment acquisition and the functions of design authority. The skills required are generally suitable for managing development when this is considered to be necessary.

11. The detailed organization of the Engineering Sub-Branch is shown in Figure 4. It is divided into five functional divisions each headed by a director general. Four of these are responsible respectively for Maritime, Ordnance, Aerospace and Communications and Electronic Systems. The fifth division is concerned with Quality Assurance and has recently been taken over from the Materiel Command, the functions of which have been absorbed into the Technical Services Branch. There is a sixth division for Systems Management which is responsible for project formulation and management and general co-ordination within the Sub-Branch.

12. All the directorates within the four environmental divisions, with the exception of the Canadian Military Electronics Standards Agency, are responsible for all aspects of equipment acquisition within the area covered by each directorate. Their responsibilities therefore cover development, feasibility studies, engineering, technical evaluation, design authority, monitoring of foreign technical activities, etc.

13. The Canadian Military Electronics Standards Agency (CAMESA) is responsible for standards and specifications for all electronic and related

components used by the Armed Forces and for maintaining adequate standards for industrial test activities by co-operating contractors.

14. The Directorate of Engineering Standardization and Services (DESS), within the Systems Management Division, is responsible for all other aspects of engineering standardization, engineering procedures and specifications (other than those related to electronics) within the Armed Forces.

15. Three test establishments fall within the purview of the environmental divisions. The Aerospace Engineering and Test Establishment (AETE) is responsible to the Director General Aerospace Systems and the Land Engineering Test Establishment (LETE) to the Director General Ordnance Systems. These two establishments are concerned primarily with the engineering test and evaluation of equipment prior to its introduction into the military inventory but they also undertake a limited amount of development work. The Director General Maritime Systems is responsible for the Naval Engineering Test Establishment (NETE) with somewhat analogous functions but this establishment is operated and staffed by a contractor.

16. Abbreviated terms of reference for some of the relevant senior officers are contained in Annex B.

17. *Organizational Arrangements with Other Departments and Agencies* — While DRB and the Armed Forces are responsible to the same Minister it is important to identify the various formal channels through which contact is maintained. These are listed in Annex C.

18. In the context of CTS/DRB relations, it should be noted that the Scientific Assistant to CTS has a non-line function on the staff of the CTS and at the same time is on the staff of the Deputy Chairman (Scientific) within DRB. This officer is broadly responsible for ensuring that the scientific and technical resources available to DRB are utilized to best effect within the Technical Services Branch. The terms of reference of this officer are also included in Annex B. Parallel positions, Scientific Assistants to the Vice Chief of the Defence Staff (VCDS) and the Chief of Personnel (CP), exist within the respective Branches.

19. Since the Department of Defence Production (DDP) is responsible for all contracting arrangements and purchasing on behalf of DND, there are close relationships between the two departments. Communication occurs at all levels on the basis of normal staff work.

20. DND is actively concerned with defence development projects initiated by the Department of Industry (DOI). Formal channels are achieved through membership of the ADM (Logistics) and Deputy Chairman (Scientific)/DRB on the Inter-Departmental Committee for Export Development and Armed Forces and DRB representation on the three subsidiary advisory groups.

21. The Armed Forces have close association with the National Research Council but the only formal special channel is through the membership of the CTS on the National Aeronautical Research Committee.

22. *Formal Agreements with Organizations outside Canada* — DND participates in various international activities related to research and development which are based on formal agreements with other governments or their agencies. The following list includes the most important and Annex D contains further detail:

(a) The Technical Co-operation Program (TTCP);

(b) The NATO Conference of National Armaments Directors (CONAD);

(c) The ABCA Armies (Quadripartite) Standardization Group;

(d) The Naval Tripartite Standardization Program;

(e) The Air Standardization Co-ordinating Committee; and

(f) Bilateral agreements with Britain, France and the USA.

23. *Overseas Offices* — The Armed Forces do not maintain special offices overseas concerned exclusively with scientific affairs but in general depend upon DRB liaison offices when these exist. There is, however, a considerable number of military attachés at embassies throughout the world who have a responsibility for keeping informed about the latest equipment and new military concepts.

Organizational Functions

24. The functions of the Armed Forces with respect to Development have been described in paras 9 and 10 above.

25. *Development Policy* — A broad statement of government policy concerning defence development is contained in the White Paper on Defence published in 1964. The appropriate extract is reproduced in Annex E. A more detailed statement of the DND policy was approved by the Defence Council in February, 1965. This is reproduced in Annex F. The salient features of this policy statement are:

(a) Major equipment needs will be met largely by purchase of allied equipment.

(b) Development will be undertaken to meet unique Canadian needs or to exploit novel concepts.

(c) Development activity is essential to train competent technical officers required to make judgments on equipment acquisition and to be responsible for operating and maintaining complex equipment.

(d) Canadian development is essential to ensure that allied technical information will continue to be supplied to us.

(e) Economic factors will be taken into consideration in selecting projects.

(f) Every attempt will be made to participate in joint development projects with our allies.

(g) Risks will be reduced by undertaking adequate feasibility and cost effectiveness studies before initiating major projects and by using adequate progress review techniques.

26. *External Relations* — The Canadian Forces Development Program involves relationships with a number of other government departments and agencies.

The closest relationship is, quite naturally, that between the Development Program and the activities of the Defence Research Board. Less involved but assisting on specific development projects are the National Research Council and the Department of Energy, Mines and Resources. There is also a point of contact with the Department of Transport on matters concerned with meteorology but this has no direct bearing on the Forces Development Program.

27. The basic functions of DRB in support of the Armed Forces have already been described in Part I. The support of development activities is provided by the DRB establishments and usually takes the form of (a) assisting in the monitoring and control of the overall program and (b) conducting or assisting in the carrying out of specific projects. Strong efforts are made to establish close working contacts between the scientific and technical groups of experts in the establishments and the engineering groups with the Technical Branch of the Forces. However, the formal arrangements described in paras 18 and 19 are all involved. Some examples of DRB participation in development projects are listed in Annex G.

28. The National Research Council also supplies assistance to the Forces in connection with specific engineering and development activities. The areas involved are usually those in which the DRB establishments have little capability and in which there is both a military and civil requirement. Examples include the support provided by the National Aeronautical Establishment and by the Mechanical Engineering Division in matters related to propulsion systems and ship design. For many years, the Radio and Electrical Engineering Division provided substantial support in the field of radar, radio direction-finding and other related areas, but in recent years most of this support has been taken over by the Defence Research Telecommunications Establishment.

29. The Department of Energy, Mines and Resources provides support in matters related to materials and corrosion and particularly in problems associated with the maritime environment. Although not in support of development, DEMR is also responsible for supplying oceanographic and hydrographic services to DND.

30. Formal relations between the Canadian Forces and industry are, insofar as the development program is concerned, effected through either the Department of Defence Production or the Department of Industry. On virtually all of the individual development projects conducted under contract by Canadian industry, there is direct contact between the industrial firm and the officers, including civilian officers, of the Technical Branch of the Canadian Forces. This contact, however, is concerned chiefly with technical matters; contract amendments and formal financial commitments on behalf of the government are the responsibility of DDP.

31. The relationships with the Department of Industry (DOI) concern the Armed Forces involvement in development projects supported by DOI. As already indicated, DND is involved through membership on the Inter-Departmental Committee for Export Development and its three advisory groups for aerospace, electronics and weapons. The Technical Branch of the Armed Forces also provides advice by membership on most of the Project Review Groups which monitor each project. In addition, DND has often provided substantial support by supplying manpower for project management, the use of test and evaluation facilities, weapons ranges, aircraft and access to the machinery of formal defence agreements. Some examples are listed in Annex H. Occasionally projects have been funded jointly with DOI when DND has a strong interest but is not able to justify full DND funding.

32. *Program Review* — There are a number of activities which are concerned with ensuring that development is conducted in an orderly manner. As already indicated, the statement of the requirements for new equipment is made by the VCDS Branch which is then keenly interested that progress is being made in accordance with an agreed plan so that the product will be available for operational use at a planned time. Periodical reviews of individual projects are therefore conducted when appropriate.

33. In May or June of each year the entire development program is critically reviewed so that the five-year departmental program (the Integrated Defence Program) can be updated prior to estimate preparation for the following year.

34. The methods used for initiating, reviewing and managing projects are discussed below in paras 57 - 62.

35. *Discussion* — Within the stated defence development policy, a number of difficulties exist and indeed they have been apparent for many years to a greater or lesser extent. The most important relates to the obvious desire of the military staffs to obtain the maximum amount of effective equipment with the funds available. In addition, in the interests of standardization with our allies and the need for adequate and economical logistic arrangements, it is usually desirable to avoid the acquisition of unique Canadian equipment if the requirement can be met in other ways. These factors can lead to a conclusion that we should undertake no innovative Canadian development but that we should always buy equipment from our allies or manufacture it under licence in Canada. Such action would fail to achieve the longer term goals of maintaining competent technical officers, retaining access to allied technical information, preserving viable defence industries and maintaining a reasonable balance of payments in defence matters.

36. With the rapidly increasing complexity and cost of equipment, the difficulty of selecting projects which can be justified on the basis of Canadian needs alone has increased. Frequently Canadian procurement levels cannot justify the level of development expenditures required. It has therefore become apparent that potential foreign sales are a prerequisite for many Canadian development projects. At the same time it has also become increasingly apparent that defence development activities sponsored by the Department of Industry and aimed at foreign sales and industrial expansion require the support of DND in some way, to be successful. These two considerations lead to the conclusion that there is a need to view each major defence development project in a broad national sense rather than in the context of the individual interested departments.

37. The Armed Forces are greatly dependent upon the scientific and technical resources of DRB for advice and support on many development projects and also for a great deal of the technical creativity required to provide new ideas and concepts for development. The recent changes in DRB organization

have led to much closer working relations between the scientists and engineers in the DRB establishments and the military and civilian officers in the Armed Forces. It has become clear, however, that the best support is obtained from DRB establishments when there is a substantial activity in a given field covering the entire spectrum of research and development and including a knowledge in depth of existing military equipment. These areas must be selected with great care in the light of long term defence policy since they can easily take several years to establish and bring to a productive state. It is expected that DRB planning activities recently initiated will lead to the initiation or strengthening of some of these areas of activity which are relevant to military interests.

Personnel Policies

38. Prior to integration of the three Services in 1964, each had a somewhat different policy with regard to the employment of civilians. In January, 1967, the Minister approved the following general guidelines:

(a) The over-riding consideration must be the maintenance and support of the operational forces. To the extent that military positions are required in support of organizations because specialized military background is required for the training and development of military personnel, for essential rotational purposes, or to augment the operational forces, these should be provided.

(b) Subject to (a) above

(1) equal consideration is to be given to the provision of appropriate career structures for civilian staffs as for military staffs;

(2) civilian or military personnel will be employed where a choice is possible on the basis of the most economical choice; and

(3) the choice under (2) will take into consideration the availability of personnel and the cost of training them for specialized jobs, the cost of fringe benefits including pensions, the capacity to offer satisfactory opportunities in a mixed staff, and the effects, if these are inadequate, in terms of productivity and turnover.

39. These guidelines apply to all staffs and therefore cover the professional engineers of interest to the Committee. Their full effect can only be brought to bear as reorganization proceeds and new staff is hired; therefore the present organization does not fully reflect the guidelines.

40. During recent months there has been considerable activity aimed at improving civilian personnel career policies within the Engineering Sub-Branch. An inventory and appraisal program has been undertaken to identify individuals with high motivation and apparent potential for career development. At the same time, a study is being initiated to identify the type of professional required in the various elements of the organization.

41. Another study is being undertaken to participate fully in the University Recruitment Program of the Public Service Commission for professional engineers.

42. In the area of further education, assistance is available for both intramural and extramural study. The choice is dependent on the needs of the individual and the availability of suitable courses. There are few courses available within the department designed specifically for civilian professional engineers. There are, however, a large number of courses available for the training of military officers. Many of these are technical and some of them quite advanced. When appropriate, civilian officers may attend these courses.

Distribution of Activities

43. While there are important regional aspects of the overall activities of DND, the scientific aspects involving development do not have any strong regional implications which are directly under the control of the department. However, since development is conducted mainly by industry under contract, the regional pattern of available industries and the policy of awarding contracts do have strong regional implications. These two aspects are primarily the concern of DOI and DDP respectively.

44. Annex I contains some statistical data supplied by DDP showing the breakdown of research and development contracts awarded on behalf of DND. It

should be noted that the data are based on the value of contracts awarded rather than the funds expended in each year. Table 1 contains a breakdown in terms of industrial sectors and Table 2 contains regional data.

Personnel Data

45. As already indicated, it is not possible to identify specific individuals who are concerned exclusively with the scientific activities of interest to the committee. In addition, it is difficult to isolate meaningful statistical information for the military officers involved in development activities. The information supplied is therefore intended to give a general statistical impression of the characteristics of the personnel involved in scientific activities.

46. Annex J contains the statistical information which covers the Engineering Sub-Branch of the CTS Branch excluding the Canadian Military Electronics Standardization Agency and the Directorate of Engineering Standardization and Services but including the test and evaluation facilities associated with equipment acquisition. The data cover 100 civilian officers and are presented in three categories:

(a) engineers with a masters level degree;

(b) engineers with a bachelor level degree; and

(c) other engineers of professional status.

The information on military officers covers those with a bachelor or higher level academic qualification and includes graduates of the Royal Military College or equivalent military institutions.

47. The information covers the situation as it exists in August 1968. It is difficult to present information which would be exactly comparable over the previous five years because of major organizational changes during the processes of military integration and unification. As a guide, however, during the past five years there has been a reduction by between 30 and 40% of the number of officers (military and civilian) employed in the Engineering Sub-Branch. Similarly, it is difficult to forecast the future which will be dependent on a review of defence policy. It would seem, however, that there will not be any substantial increase in the level of activity unless there is a major change in the international situation.

48. The staff concerned with development as defined in Annex A represent only a modest fraction of those covered by the statistical data in Annex J. As a guideline it may be assumed that approximately 10 - 15% of this effort is on the average involved in development activity. As stated in previous paragraphs, most of the effort is used for project formulation and the management of contracts with industry and not for in-house development activity.

49. At the present time, none of the civilian professional officers is on educational leave although increasing attention is now being directed to identifying cases where such further training is required.

50. During the summer months, the department employs a number of casuals for work in the Engineering Sub-Branch and some of these could be under-graduates in the science and engineering disciplines. However, there is no formal program specifically designed to provide undergraduate students with employment in scientific activities during the summer months.

Expenditures

51. Annex K contains details of expenditures managed by the CTS in connection with his responsibilities for research and development activities on behalf of the Canadian Armed Forces. Due to the major changes in organization, personnel and procedures which occurred following the integration of the Armed Services, it has not been possible to provide in all cases the actual expenditures incurred prior to FY 65/66.

52. The source of funding shown against "Support of R & D in Industry" is that provided by the Canadian Forces Development Vote. It has been reliably estimated that between 1% and 2% of these expenditures are used for "in-house" activities but as this is such a small proportion, no adjustments have been made to the totals. Actual expenditures have been shown for FY 62/63 to FY 67/68 and that for 68/69 is the present forecast.

53. The figures shown for the various units under "Intramural R & D" are the total operating costs. However, in the case of the Engineering Sub-Branch

these are estimated personnel costs only and represent that proportion of the staff directly associated with development activities.

54. A difficulty in providing a realistic figure for total development expenditures is presented by a degree of arbitrariness during past years in the interpretation of the definition of development. For instance it has been customary, when acquiring an aircraft of foreign design to fund the entire project from the equipment primaries even though a considerable amount of modification and development of sub-systems may be involved. A rough estimate for general aircraft over several years indicates that there has been an average expenditure on development of about $6,000,000 per year on this type of activity related to aircraft.

55. Many countries consider the cost of a "lead" ship for a new class as development of a prototype. In Canada the design of a new ship and work on the hull, propulsion and machinery has not been classed as development although work on the sub-systems such as sonar, communications and armament has.

Research Policies

56. The basic policy is that development of military equipment is conducted by industry under contract. There are, however, occasions when it is preferable or necessary to undertake some work intramurally. This usually takes the form of Preliminary Development when DND possesses unique facilities or capabilities non-existent elsewhere.

57. *Project Selection, Initiation and Management* — In general, development is initiated in response to Operational Equipment Objectives (OEOs) or Operational Equipment Requirements (OERs) which are prepared and approved by the VCDS in consultation with the CTS and his staff. This process of initiation is described in more detail in Annex L.

58. The CTS is responsible for approving the initiation of significant projects or making recommendations to the CDS or the Minister for very large projects. To assist the CTS in making these decisions, there is an advisory

committee called the Development and Associated Research Policy Group (DARPG) which brings together senior officers from the Armed Forces, DRB and the Deputy Minister's office who may have involvement in development. Observers from the treasury board and the Departments of Industry and Defence Production also attend. The present composition and terms of reference for the DARPG are given in Annex M. A secretary and supporting staff for this committee are provided by the Directorate of Project Formulation (DPF) within the Systems Management Division of the CTS Branch. DPF is responsible for examining all proposals for development and for taking action to ensure that all relevant information required for a thorough appraisal of each proposal has been included.

59. When a project has been approved, the responsibility for management usually rests with an officer in one of the functional divisions of the Engineering Sub-Branch. For larger projects the DARPG, in approving project initiation, may direct that reviews of progress be provided at designated stages of the project. For very large projects a management charter is issued by the CTS designating the officer having the overall responsibility for management and detailing the duties and responsibilities of other organizational elements in regard to the project. DPM is responsible for co-ordination of the various inputs, assistance in preparing the Master Implementation Plan, maintaining records of progress, changes in plans, and the management information systems. Except where a joint interdepartmental management office exists, as discussed below, the ultimate responsibility for project management rests with the designated functional division head in the Engineering Sub-Branch. It should be understood that the term management is interpreted in the broad sense and includes not only the technical management but also all actions required within the Armed Forces to bring the equipment into operational use. This includes engineering evaluation, user evaluation, training of user personnel, establishment of logistic arrangements, displacement of existing equipment, etc.

60. During project initiation, close liaison is required with the Department of Industry (DOI). This is achieved at various staff levels and through cross-participation on the appropriate senior committees. Considerable

progress has been made in recent years in turning over promising projects to DOI for support when DND requirements alone cannot justify initiation or in arranging joint funding (as with the CL-84 tilt-wing aircraft).

61. Since the Department of Defence Production (DDP) is responsible for contract administration on behalf of DND, very close working relationships are essential. DDP is responsible for processing contract demands initiated by DND and thus conducts tender action, bid assessment and final contract action. These actions involve DND staffs but ultimate decisions on contractor selection are made by DDP in the light of DND recommendations. DDP thus plays a key role in the choice of contractor for DND work.

62. In addition, in view of DDP's responsibility for contract administration, that department is also concerned with project management. For major projects, joint project management offices are established with DND and DDP staffs. When the project is funded by DND, the project manager is a DND officer and his deputy a DDP officer and when the project is funded by DOI, the reverse arrangement is used. The project manager is responsible to a policy board consisting of senior officers from the departments involved. Joint project offices exist for several projects concerned with the procurement of major equipment but the only development project so managed is the FHE-400 Hydrofoil.

63. *Priorities* — Priorities for equipment acquisition are established by the VCDS Branch and are stated in terms of three levels based on the possible improvement to operational capabilities. They are used mainly in connection with project selection required to make changes to the five-year integrated defence program (IDP).

64. These priority levels are not generally used for the development projects but, of course, the ultimate potential availability of funds for equipment procurement has an important bearing on any decisions to proceed with development.

65. *Management Techniques* — Essentially all development projects utilize some form of planning and review technique. For simple projects this may be

no more than the identification of milestones or review points but, for major projects, CPN or PERT will probably be used. Examples of major projects using PERT are:

(a) the $1\frac{1}{4}$ ton utility truck (Dodge RAM);

(b) the FHE Hydrofoil ship; and

(c) the development of the SEA SPARROW for installation in the DDH 280 class of ships.

66. In addition, a management information system (PROMIS) has recently been introduced into the CTS Branch for selected equipment acquisition projects. A brief note on PROMIS is contained in Annex N.

67. *Balance between Intramural and Extramural Projects* — As already indicated, the standard DND policy is that Engineering Development and Operational Systems Development should be undertaken by industry. The activities undertaken within the Armed Forces generally fall in the following categories:

(a) systems analysis and studies required in concept formulation;

(b) design and prototype production of modifications to equipment such as aircraft or kits for fighting vehicles;

(c) engineering test and evaluation requiring military personnel and specialized facilities and equipment;

(d) work on breadboard or experimental models when appropriate in existing facilities; and

(e) management of contracts.

68. Some of this type of work may be undertaken by DRB establishments on behalf of the Armed Forces when suitable skills and facilities exist.

69. *Changing Programs* — In contrast to programs of scientific research, the development program has relatively shorter term objectives aimed at meeting

specific equipment needs by the application of existing or anticipated technology. The development program pattern is therefore governed by:

(a) the existence of equipment requirements;

(b) the availability of technology; and

(c) the availability of funds.

Within these considerations the program is determined within the system already described.

Research Output

70. The results of Canadian Forces development activity differ from those of research in that the primary output is in the form of prototype hardware as opposed to publications in scientific journals and papers presented to learned societies. There is, however, a certain amount of this activity, mostly concerned with patents.

71. The policy of the Department of National Defence on patents as dictated by a Treasury Board ruling is primarily a defensive one; i.e., patents are obtained to prevent the payment of royalties and fees to others rather than to seek royalty income. Where the possibility of obtaining a patent exists, an attempt to obtain such protection is made for every invention that is the product of the department's research and development provided that possible use by the Crown can be disclosed. It is the normal practice to file patent applications in Britain and the USA but, under the various international agreements discussed elsewhere, reciprocal arrangements are made whereby one country will process applications and obtain its own national patents in the name of the country responsible for the invention. Provision has been made for filing patents in secrecy where security considerations so dictate.

72. During the period from FY 63/64 to the present, a total of 20 licences has been granted by the Crown on patents taken out by DND (including DRB). During the same period patents taken out as a result of work undertaken by DND have resulted in royalty fees paid to the Crown amounting to $906,000. It should be noted that royalty-free licences are on occasion granted to Canadian companies.

73. Although as stated above, it is not a primary objective of departmental patent policy to obtain royalties, it is worth noting that a single invention (an aircraft navigation system for use in northern latitudes) has resulted in royalty payments to the Crown of over $1,000,000 over the 10-year period since its invention.

74. Books, journal articles, reports, etc., do not normally result from development projects. Prototype equipment, specifications and designs for such equipment are the principal outputs of the programs. Dissemination of the results of development projects to allied nations often takes the form of demonstrations of prototype equipments. Arrangements for these demonstrations are made jointly by the Armed Forces, the Department of Defence Production and the commercial contractor. The aim is not to obtain scientific recognition for the effort but rather to promote sales to foreign defence organizations. The results of development activity are also disseminated promptly and in detail amongst our allies through the media of the various international arrangements already described.

75. These contributions to the international pool of knowledge, along with the research contribution made by DRB, are responsible for making available a vast amount of technical information from other countries. This information is obtained at meetings, by visits to agencies in other countries and through formal information channels. The Defence Scientific Information Service (DSIS) in DRB provides the formal scientific information channel for all at DND. DSIS can, in turn, make this information available to extramural agencies including contractors when the need exists.

76. The Armed Forces have not, in general, created internationally-recognized teams or scientists of international repute because of the nature of their work. However the work done by the military and civilian technical officers has frequently been recognized within the international defence community as being of high quality. In addition there has been a small number of officers with extremely high technical creativeness; these officers have produced ideas which have been developed by industry and which have led to

substantial foreign sales. It is unfortunate that financial and manpower constraints in recent years have essentially eliminated the favourable climate for this type of activity.

77. The technical competence of many military officers is also well demonstrated by the large number now employed by DDP, DOI and other departments following their retirement.

78. It has been recognized in most countries that defence-sponsored research and development has been of inestimable value in stimulating technological advance and creating a highly developed industrial base. It is likely that the highly competitive aspects of defence required to maintain national sovereignty and influence, instil into military research and development a sense of urgency not always so apparent in other areas of national endeavour.

79. The competence and industrial base so established has produced large dividends for the domestic economy and a countless stream of products not consciously associated with defence. The modern electronics and aircraft industries produce perhaps the most startling examples. This situation is less obvious in Canada than in the USA because of the much lower level of activity but the experience of other countries would suggest that a withdrawal from military research and development would have a serious effect on the national economy in the long term. It is significant that the period of most rapid economic and industrial expansion in Canada which followed World War II occurred immediately after the creation of a large military research and development community during the war.

Projects

80. Annex O displays the 68/69 Development Program of the Canadian Armed Forces in terms of Technical Fields, and the estimated time scale for each project. A few projects which appeared in the 66/67 Development Program, but have since been completed, have been included to further illustrate the scope of the activities following integration of the Armed Forces. Projects are classified in the listing, as either "Term" or "Recurring". Term Projects, shown with a bar to illustrate the time schedule, are usually undertaken in

response to an operational requirement, i.e., the Aim, Program, Funding and Time Schedule can be stated with reasonable accuracy. Recurring projects represent a continuing requirement in a specific Technical Field and cover such activities as investigations and improvements to existing equipment, maintaining and improving technical competence and the conduct of feasibility studies, Project Definition and Evaluation of equipment to satisfy service requirements. The individual projects usually involve a number of specific tasks which can be defined precisely and which do have a finite duration.

81. ANNEXES P—V contain briefs on six specific projects which have been supported by the Armed Forces development program. The Doppler radar project is a striking example of a successful project arising from DND research and development followed by industrial exploitation and ultimately by substantial foreign sales.

Impact of Science and Technology on Future DND Activities

82. *Equipment Aspects* — It is inevitable that defence-oriented research and development will continue to push forward the frontiers of technology at the maximum rate to achieve excellence in future weapon systems. It would be simple to say that all technological advances will be applied to a greater or lesser extent in future defence systems. It would be much more difficult to make judgments on the relative value of advances in particular technologies to the overall military capability.

83. A major planning function involves this problem of relating the relevance and value of various technologies to military capability and then in turn the relevance of various scientific disciplines to the technologies. This is a difficult and complex problem and studies of the methodology best suited to Canadian defence needs have only recently been started.

84. As already indicated, it is impossible to conduct a broadly based research and development program aimed at meeting all Canadian equipment needs. Optimum planning therefore involves the complex process of superimposing many other factors upon the relevance of scientific disciplines to technologies and in turn to military capabilities; these include such factors as economic and industrial interests, available technical resources, etc.

85. Regardless of this complex planning process aimed at defining an optimum research and development program, the Canadian Forces can probably expect to continue to be provided with equipment based on the most advanced technologies developed mainly by our allies.

86. *Management and Decision-Making Aspects* — The very high cost and complexity of defence projects have led to much pioneering of management techniques in the defence field. The concepts of project managers, project offices, the total system approach to management, PERT, etc., have all been either created or developed greatly in relation to defence projects. Many of these new techniques are being actively employed in the non-defence field.

87. Similarly, the techniques of operational research and systems analysis were developed in the defence field and are now being applied extensively elsewhere. In more recent years the concept of planning-programming-budgeting was first applied to the US Department of Defence and subsequently applied to other departments and in other countries.

88. It seems reasonable to expect that the defence community will continue to pioneer new techniques of management and decision-making and DND will unquestionably attempt to contribute to this process and adapt the techniques developed elsewhere to Canadian needs.

89. Many of these techniques have become useful through the availability of smaller more versatile computers and data processing equipment. The next few years will see the extensive application of these techniques to the management of military operations. Studies are already well advanced of an integrated logistics and supply for the Canadian Forces based upon the most recent data processing and communications techniques. Similar techniques are being and will increasingly be applied to the handling of battlefield information and to the effective command and control of military units and formations.

TESTING AND STANDARDIZATION ACTIVITIES

90. This section will cover the activities of three elements of the organization which are concerned with the testing and standardization required in direct support of the equipment acquisition function.

(a) The Directorate of Engineering Standards and Services (DESS);

(b) The Canadian Military Electronics Standardization Agency (CAMESA); and

(c) The Quality Assurance Division of the Engineering Sub-Branch (QAB).

Some aspects of the activities of the three test establishments referred to in para 15 should strictly fall in this category but since some of their functions fall within the DND definitions of development (which include test and evaluation) it would be extremely difficult to sub-divide their functions. They were therefore covered in the previous section.

Directorate of Engineering Standards and Services (DESS)

91. As indicated in para 14, DESS forms part of the Systems Management Division of the CTS Branch and is broadly responsible for the standardization of engineering procedures, practices and philosophies. Its functions are:

(a) the development of engineering standards within DND, nationally and internationally;

(b) the management, on behalf of the design authority, of the manufacturing data used to describe DND requirements; and

(c) co-ordination of patent and invention matters.

92. It is the policy of the department to achieve the maximum degree of standardization with other friendly nations and many of the formal agreements identified in the previous sections are used for this purpose in connection with the activities of DESS. The directorate thus provides or arranges for representation to the wide range of committees both in Canada and internationally and in addition provides the necessary co-ordination to determine the required extent of participation.

93. The operating cost data for DESS are included in Annex V which summarizes the total cost of testing and standardization activities. The total staff is 29 and of these, 5 are professional engineers.

Canadian Military Electronics Standardization Agency (CAMESA)

94. As stated in para 13, CAMESA forms part of the Electronics and Communications Division of the CTS Branch. The Agency provides support to the procurement and maintenance of electronic equipment and materials for the Armed Forces involving the following basic functions:

(a) applications engineering;

(b) document provisioning;

(c) qualification approval management;

(d) reliability assessment; and

(e) laboratory program management.

A more detailed description of these functions and the terms of reference for the Agency are included in Annex W.

95. In addition to making contributions to the Canadian participation in the various formal international agreements already referred to, CAMESA is involved in other formal agreements which relate to Canada/USA defence economic co-operation. These are identified in Annex W.

96. CAMESA is also involved in a wide range of co-operative activities with other departments and agencies in Canada and in representing Canadian interests in international activities. Further details are provided in Annex W.

97. The operating cost data for CAMESA are included in Annex V. It should be noted that the laboratory functions were transferred to the Quality Assurance Laboratories during 1967/68. The Agency has a staff of 34 of which 5 are professional engineers.

98. The output of CAMESA is primarily utilized directly in support of procurement and maintenance activities and consists of documents such as specifications, qualified products lists, preferred parts lists and test reports covering the performance of specific products.

Quality Assurance Division

99. As already stated this component of the organization is being taken over as a division of the Engineering Sub-Branch with the absorption of the

Materiel Command by the CTS Branch. Since the re-organization plans have not yet been completed, the data supplied are based upon the organization with the Materiel Command, which is known as the Quality Assurance Branch (QAB).

100. QAB is responsible for providing assurance that new materiel entering the DND inventory is in accordance with approved specifications and that materiel repaired or modified by contract meets acceptable standards when QAB is named in the contract. Detailed terms of reference are contained in Annex X.

101. The Quality Assurance Branch is divided into three main Divisions: the Quality Assurance Engineering Division, Quality Assurance Laboratories Division and the Quality Assurance Support Services Division. Details of the functions of the Divisions are provided in Annex X and a block diagram of the organization is shown in Appendix I to Annex X.

102. QAB is involved in activities arising from the international agreements already referred to and, in addition, is concerned with others more specifically related to quality assurance. There are also many co-operative activities with other departments and agencies. Annex X contains additional detailed information.

103. Operating cost data for the QAB are contained in Annex V. The staff presently consists of:

(a) Professional scientists/engineers	45
(b) Military officers	10
(c) Technical support/civilian	961
(d) Other military	12
(e) Other civilian	124
	1152

104. The major output of the organization is not in the form of scientific papers, articles, etc., because of its functions. However, in support of these functions, a number of technique studies and investigations have been undertaken. Annex X contains further details.

CONCLUSIONS AND RECOMMENDATIONS

105. Examination of the information presented in this Part of the Submission shows that the activities within the Forces which fall within the purview of the committee are surrounded by a number of difficulties. These will be discussed in this section and some conclusions and recommendations presented.

Level of Effort

106. The total cost of all development, test and evaluation activities is difficult to arrive at precisely because of problems of definition and accounting. However, it is clear that it is of the order of 1.5 to 2.0% of the defence budget. By any standards for an industrial country this is low. On the other hand, development (including test and evaluation) amounts to about 10% of the equipment acquisition funds. When the nature of the expenditure on development is examined, it is apparent that a major proportion of the activity can not be classed as innovative development but consists of procurement for test and evaluation of equipment, operation of evaluation facilities, interface engineering, adaptation of equipment, etc. With a few notable exceptions (e.g., the hydrofoil) the development program in general does not represent logical application of the products of the research program. On the contrary, the competence created by the research program is generally used to support the Armed Forces in conducting analysis related to equipment acquisition decisions and in contributing to and assisting in development projects initiated by the Forces. Within the declining manpower level of th. Forces, it can be expected that DRB will be pressed to take on increasing responsibilities in this field.

Relations of the Armed Forces with DRB

107. The organizational separation of the responsibility for research from that for development, test and evaluation has obvious advantages in maintaining an independent civilian defence science community relatively free of military pressures and of high calibre because of its special personnel arrangements. However, any such interface presents difficulties because of the need for a smooth transition between research and development. Changes made in recent years, including the creation of the Development and Associated Research Policy Group, the location of DRB staff within the Forces

organization and the reorganization of DRB have all improved the situation. It should be recognized that all countries have been seeking an optimum organization for defence research and development for many years and also that this is only one of several interfaces in the equipment acquisition cycle. Others relate to engineering, maintenance, supply and requirements definition.

Relations with DDP and DOI

108. So long as DDP (or its successor) retains the authority for defence contracting, its relations with DND will be complex. The relative responsibilities of the two departments are clear and therefore, for all projects, a degree of joint management is unavoidable. For large and complex projects a joint management office will be essential. With such arrangements, only a spirit of goodwill and mutual understanding can lead to harmonious management.

109. The division of responsibilities between DOI and DND is perhaps less clearly defined. It is perhaps anachronistic that the DOI development program is larger than that of DND. While DND makes a substantial contribution to this program in the form of assistance and advice, many of the projects are of no interest, or at most of secondary interest to DND. On the other hand, it has become increasingly apparent that export potential of the products is greatly enhanced by more substantial DND involvement.

110. The co-ordination arrangements between DOI and DND have been greatly improved in recent years but there are difficulties in the effective formulation of projects which meet criteria of (a) value to DND in meeting Canadian requirements, (b) value to DOI in expanding exports and (c) value to industry in fostering expansion.

The Case for Defence Development in Canada

111. Because of the difficulties inherent in the relative smallness of the Canadian Armed Forces and the scarcity of funds and qualified manpower for management of projects, it is reasonable to question why DND should support development projects rather than purchase all equipment from our allies or manufacture it under licence in Canada. It is considered essential to retain defence development activity for the following reasons:

(a) to maintain an up-to-date knowledge of advanced technology in order to conduct the analysis and assessment required for equipment acquisition decision-making;

(b) to meet uniquely Canadian needs;

(c) to exploit novel concepts arising from Canadian research;

(d) to make a contribution to the pool of allied technical knowledge so that access to this immense collection of information and advice can be maintained;

(e) to assist in the preservation and expansion of industries based on advanced technology; and

(f) to maintain the body of competent technical officers required to operate and maintain modern complex equipment.

Development Policies

112. It is recognized that much of the equipment required by the Forces will be purchased from our allies or manufactured under licence in Canada. The small volume of Canadian requirements can usually not justify development in Canada unless an export potential can be identified. Therefore it is inevitable that major development projects will be few and they need to be selected with great care. It is obvious that it is desirable to attempt to participate in development projects in co-operation with our allies whenever possible.

113. Much of the development activity will be concerned with improvements to existing equipment, adaptation of equipment to meet Canadian needs, and the development of sub-systems based on Canadian innovation.

114. Whenever possible development is conducted by industry although projects are occasionally conducted intramurally when unique facilities or resources existing only within DND are required or when appropriate

industrial competence is not available. The DRB establishments are often involved in the demonstration of the feasibility of novel concepts.

International Involvement

115. There is a complex network of both formal and informal agreements covering the exchange of defence scientific and technical information of a classified and unclassified nature. Apart from the industrial and economic advantages of international co-operation in development projects, our contribution to this pool of knowledge opens up a vast store of technical information essential to sound decisions. Much of this information is also of immense value to the non-defence community because defence research and development has often been responsible for the exploitation of scientific advances and the rapid expansion of new technology.

Personnel

116. It is difficult to draw conclusions regarding the personnel involved in the scientific activities of the Armed Forces because the officers (civilian and military) are not wholly involved in these activities but are concerned with the entire spectrum of equipment acquisition functions.

117. The subject is also complicated by the mixture of military and civilian staffs within the technical arm of the Forces. The policy is to use civilian officers when it is most economical and does not prejudice the maintenance and support of the operational forces either directly or indirectly. Civilian officers are in general less costly and they provide a degree of continuity not possible with military officers who may be transferred frequently and at short notice. On the other hand, too heavy a dependence on civilian officers may provide inadequate training opportunities for military officers and an underestimation of the military factors which relate to equipment.

118. Earlier policies had led to a somewhat unsatisfactory career development pattern for civilian officers. It is hoped that recent changes will have improved this situation considerably.

Management

119. The magnitude and complexity of defence projects has led to the development of many new management techniques concerned both with decision-making and project implementation. The use of systems analysis and management techniques such as PERT have become firmly established.

120. In attempts to minimize cost escalation and slippage, so common in development projects, new procedures have recently been established by the Forces for defining requirements, formulating projects, developing implementation plans and reviewing projects. These are being applied to development projects but it is, as yet, too soon to assess the improvement that has been achieved.

Test Establishments

121. The three test establishments represent a substantial proportion of the activities which fall within the definition of development. Most of their work, however, is concerned with equipment acquired through purchase rather than from a Canadian development program. Regardless of the level of true development activity, these facilities will be essential to ensure that equipment supplied to the Forces performs in an acceptable, safe and reliable manner.

Standardization

122. The three departmental activities concerned with standardization also represent a substantial level of expenditure. Their functions are, however, inherent in the need of DND for the acquisition of a large amount and great diversity of materiel ranging from highly complex equipment to routine supplies.

Recommendations

123. Recommendations concerned with defence equipment development and associated activities are related to three principal factors. Firstly, in view of the high cost and complexity of equipment, it is inevitable that the interests of several departments will be involved as well as those of industry. There is a need to formulate and implement projects in the overall

national interest. Secondly, the acquisition of military equipment presents certain problems concerned with the need to maintain a strong military involvement during all stages of equipment acquisition in order to ensure that the equipment is ultimately operationally acceptable. Thirdly, the defence community has created an extremely comprehensive and effective machinery for the international exchange of technological information, often absent because of proprietary considerations in fields of non-defence interest.

124. The following specific recommendations are therefore made:

(1) In any consideration of inter-departmental or inter-agency reorganization, serious consideration should be given to the need to create a suitable climate and improved machinery for initiating and conducting development projects which can serve the overall national interests.

(2) In any consideration of reorganization, the vital importance of retaining military involvement and influence on military equipment projects should be recognized.

(3) The extensive machinery within the defence community for the international exchange of technological information should be recognized as being of vital importance to the overall national technological capability.

DEFINITION OF RESEARCH AND DEVELOPMENT TERMINOLOGY USED IN DND

BASIC RESEARCH

Basic Research is research carried out to increase the accumulated, objective, and systematic knowledge of the inherent properties of matter, space, energy, natural phenomena and biosystems and their interactions. There are two prime motivations for doing basic research. One is composed of curiosity and personal tastes; the other is a serious deficiency in existing knowledge which is recognized as being a real or potential barrier to scientific understanding and technological advances. When pursued for the latter reason it is termed *"objective basic research"* and, in the defence context, the knowledge deficiency must have substantial defence implications to qualify the research as objective basic research.

APPLIED RESEARCH

Applied Research includes all effort *concerned with the application of knowledge, materials and/or techniques* to the solution of specific military problems short of development activity. It may involve studies, investigations and the construction of breadboard hardware. The dominant characteristic of this category of effort is that it is directed toward identifying and evaluating the feasibility and practicability of new concepts, techniques or military materiel. The effort may lead to the formulation of OEOs and OERs.

PRELIMINARY DEVELOPMENT

Preliminary Development includes systems analysis, feasibility studies, trade-off studies and projects which require the development or use of hardware for technical evaluation or operational test as opposed to design and engineering of hardware for eventual military use. This category of effort will usually be undertaken in response to an OEO and be aimed at the formulation of an OER.

ENGINEERING DEVELOPMENT

Engineering Development includes all projects which require engineering, test and evaluation of systems, sub-systems or equipment for military use but

for which production and deployment has not been approved. This category of effort will be conducted in response to an OER.

OPERATIONAL SYSTEMS DEVELOPMENT

Operational Systems Development includes research and development effort directed toward the acquisition of systems, sub-systems or equipment that have been approved for production and deployment. All activities in this category will be in support of procurement activity.

OPERATIONAL EQUIPMENT OBJECTIVE (OEO)

This document outlines a broad statement of military need for a system or equipment family. One or more concepts may be identifiable but the military, technical or cost feasibility will not be clear.

OPERATIONAL EQUIPMENT REQUIREMENT (OER)

This document is a clear, precise and detailed statement of the operational characteristics of the equipments and facilities which comprise the system, together with the personnel requirements.

TECHNICAL APPROACH (TA)

This document presents operationally, technically and financially feasible system options for accomplishing the objectives set forth in the OEO.

SYSTEM PLAN (SP)

This document presents operationally, technically and financially feasible system options for accomplishing the requirements set forth in the OER.

ANNEX B

FUNCTIONS OF SENIOR OFFICERS WITHIN CANADIAN FORCES HEADQUARTERS

Vice Chief of Defence Staff. (VCDS) is responsible for operational tactical and strategic planning, intelligence, the defence programming system (IDP), force structure, operational concepts, equipment requirements, priorities for allocation of resources, operational research, operational readiness, operational training, the reserves and cadets, national survival, civil emergency, flight safety and nuclear weapons.

Chief of Technical Services. (CTS) is responsible for policies and plans and their implementation relating to development, engineering, procurement and installation of equipment, the supply system for all materiel needs, the movement of all materiel and personnel, the construction, maintenance and operation of all accommodation and for some aspects of telecommunications.

Scientific Assistant to CTS. (SA/CTS) is responsible for supplying scientific and technical assistance to the CTS Branch by using all available DRB resources and other resources to which DRB may have access and for undertaking special studies as required by the CTS.

Deputy Chief for Engineering. (DCENG) is responsible for development, design, acquisition and manufacture of all equipment and systems and the technical direction and approval of design changes for all equipment.

Director General Systems Management. (DGSM) is responsible within DCENG for the formulation, implementation and management of all equipment acquisition projects, formulation of development policy, financial matters, engineering standards, services and procedures and the co-ordination of various sub-branch matters.

Director General Maritime Systems. (DGMS) is responsible in the field of maritime equipment for development, systems engineering, acquisition, studies, test, evaluation, design authority functions, product improvement, technical advice, technical liaison and knowledge of appropriate technology.

Director General Aerospace Systems. (DGAS) has analogous responsibilities to DGMS in the aerospace field.

Director General Ordnance Systems. (DGOS) has analogous responsibilities to DGMS in the ordnance field.

Director General Communications and Electronics Systems. (DGCES) has analogous responsibilities to DGMS in the field of electronics and communications and in addition a responsibility for the operation of fixed communications facilities.

ANNEX C

FORMAL DRB/MILITARY RELATIONS

The following formal channels of communication exist between DRB and the Armed Forces:

Defence Council. The Chairman, DRB is a full member of the Defence Council and the Vice-Chairman is an associate member.

Chief of Defence Staff Advisory Committee. The Chairman, DRB is an associate member of the CDS Advisory Committee.

Defence Research Board. The Chief of the Defence Staff, the Vice Chief of the Defence Staff and the Chief of Technical Services are members of the Defence Research Board.

Defence Research Council. The Deputy Chief Force Development is a member of the Defence Research Council.

Development and Associated Research Policy Group. See Annex M.

Scientific Assistants to the VCDS and the CTS. See Annex B for terms of reference for SA/CTS. SA/VCDS has essentially parallel functions within the VCDS Branch.

ANNEX D

FORMAL AGREEMENTS WITH ORGANIZATIONS OUTSIDE CANADA

The Armed Forces are involved in contributing to the following activities:

(a) The Technical Cooperation Program (TTCP)

This program was initiated by an exchange of notes between the governments of the US, UK and Canada in 1957-58, and Australia was admitted in 1965. Under the Combined Policy Committee, consisting of the Foreign and Defence Ministers of the member nations, current activity is largely confined to the sub committee on Non Atomic Military Research and Development (NAMRAD). The Defence Research organizations of the member nations are the participating specialist national agencies. Activities through the medium of sub groups consist largely of exchange of information, by means of correspondence, reports, meetings, symposia and the exchange of scientific personnel. Canadian Forces officers with appropriate technical qualifications are, by invitation of the National Leaders, members of a number of the sub groups and working panels.

(b) The NATO Conference of National Armaments Directors (CONAD)

This group, to which the DM/DND is the Senior Canadian representative, has the aim of coordinating military research, development and production activities between the NATO countries. The following groups report to the CONAD:

The NATO Air Force Armaments Group;

The NATO Naval Armaments Group;

The NATO Army Armaments Group; and

The NATO Defence Research Group.

Formation of a fifth group, the NATO Defence Logistics Group, has been proposed and is at present under study. Each of the Armaments Groups is sub-divided into specialist sub groups in which representatives of interested nations meet to discuss mutual problems.

Although the ultimate aim of this activity is the shared development and production of armaments systems, studies and information exchange have heretofore been the principle benefit to participating nations.

(c) The ABCA Armies (Quadripartite) Standardization Group

This group is organized under the terms of the ABCA Basic Standardization Agreement and includes the armies of the US, UK, Australia and Canada, with New Zealand having Observer status under Australian auspices. Through the medium of some twenty-two specialist working groups the member armies exchange information regarding materiel and non-materiel matters and are thus afforded the means to influence and participate in each other's development and production activities. The group maintains close liaison with TTCP which is considered to have the prime responsibility in research matters.

(d) The Naval Tripartite Standardization Program

This program provides the machinery for the exchange of information regarding specified projects between the navies of the US, UK and Canada; however, it has been virtually dormant in recent years except in the area of Engineering Practices.

(e) The Air Standardization Coordinating Committee

This is the Air Force counterpart of the ABCA Armies Standardization Group. Unlike the latter, the Air group tend to exclude Research and Development in basic equipment from their common activities and concentrate upon standardization of procedures, tactics, materiel and servicing facilities.

(f) Bilateral Agreements

The principal Bilateral Agreements in which DND is involved are the Anglo-Canadian, the Franco-Canadian and (in an advisory capacity) the Development and Production Sharing agreement between DDP and the DOD in the USA.

(1) *The Anglo-Canadian Committee on Cooperation in Research, Development and Production.* The Armed Forces participate in this activity largely in support of DDP and DOI interests.

(2) *The Franco-Canadian Agreement concerning Cooperation in Research, Development and Production of Defence Equipment.* This agreement, formally ratified at the end of 1967, is also of prime interest to DDP and DOI.

(3) *The Development and Production Sharing Agreement between DDP-DOD.* DND acts in an advisory capacity to DDP in this activity which has led to the securing of a number of US development contracts by Canadian companies. Canadian financial assistance where necessary is provided through Vote 5, under the supervision of the Interdepartmental Committee on Defence Export Development.

ANNEX E

EXTRACT FROM 1964 WHITE PAPER ON DEFENCE

The following extract is taken from Section VI of the 1964 White Paper dealing with "Defence Research and Industry":

DEVELOPMENT

Development of military equipment within the Department of National Defence is the responsibility of the Armed Forces and represents specialized technological interests of the Services concerned. Actual development of such specific requirements, together with certain joint development projects under the auspices of standardization agreements with allied countries, is generally conducted in industry and is limited to items not available from other programs, domestic or allied. The result of conducting such development in industry is to improve industrial defence technology and thereby enhance the ability of Canadian firms to participate in co-operative development and production-sharing programs with allied countries.

With the co-operation of the Department of National Defence, the Department of Defence Production administers the Development-Sharing Assistance program in which military equipment and materiel is developed for potential use by the nation's allies. The projects are conducted entirely in industry and costs are shared between the Department of Defence Production, the industrial firm conducting the development and, in many cases, the military department of the allied country having an interest in the development.

For the future, a dynamic defence research and development program is an essential element of our defence policy. It is our intention not only to support it fully, but also to implement a gradual but consistent increase in the resources made available for such a program.

ANNEX F

DND DEVELOPMENT POLICY

(Approved by Defence Council - February 1965)

PREAMBLE

1. Recognizing the necessity of development to meet equipment needs of the Services and its desirability, both as an element in the advanced technological education of Service technical officers and as a means of gaining detailed cognizance of the development activity of allied Services, the Department of National Defence will undertake development in accordance with the policy set down hereunder.

2. The primary reason for a Canadian Forces' development program is the provision of adequate equipment. A secondary but nevertheless important reason is the acquisition of technical knowledge. Because of the complexity and expense of modern equipment there will be few cases where major development programs are justified on Canadian requirements alone. The emphasis must inevitably be upon cooperative programs with Canada's allies and upon the purchase of suitable equipment from allied sources. Service technical officers employed in choosing, evaluating, maintaining and operating such equipment require a standard of technical proficiency which can only be obtained from direct contact with development programs. Furthermore, an active development program is a prerequisite to receipt of much technical information from Canada's allies.

GENERAL POLICY

3. Under the general heading of Development, the Department of National Defence will undertake programs in the following categories:

(a) The development of new equipment and materiel to meet operational requirements.

(b) Participation with allied Service(s) in development projects of interest to the Canadian Services.

(c) The improvement of existing equipment in order to increase its operational effectiveness and technical adequacy.

(d) Participation with allied countries in improvement of weapons and equipment of interest to the Canadian Services.

(e) Technical test and evaluation of systems, equipment and materiel to determine their suitability for adoption by the Canadian Services.

(f) Technical investigations relating to possible future systems and equipment.

4. It is fully recognized that an element of risk exists in many development programs. However, the risk will be reduced as far as possible by scientific, technical and operational assessments undertaken in order to estimate the operational effectiveness, cost and the extent to which existing engineering technology can cope with the foreseeable development problems.

5. While the primary criterion in deciding on new major development projects will be the Canadian military requirement, consideration will also be given in major new programs to the impact on Canadian industry. Furthermore, the impact of Canadian industry will be a factor in determining the overall level of the defence development program.

ELABORATION OF POLICY

6. DEVELOPMENT

(a) Development of New Equipment

In order that Canada, with comparatively small fighting forces, may make a worthy defence contribution, the Canadian Forces have need of the most effective modern weapons and equipment possible, consistent with financial, manpower and logistic limitations. This implies access to an active development source, either Canadian or foreign.

Modern weapons and weapons systems are generally very complex and costly. For this reason Canada must depend largely on the developments of her major allies to meet most of the weapons requirements of the Armed Services.

Nevertheless there will be occasions when weapons and equipment required by the Canadian Services are not readily available from outside sources and can be provided only by Canadian development. On other occasions research will suggest possibilities for valuable military developments which it will appear most desirable to pursue, both for their value in meeting Canadian requirements and for their possible value to allied countries.

(b) Participation in the Development of New Equipment

Within the NATO alliance there is a strong desire to improve cooperation in military research, development and production. There exists an obligation and opportunities to participate in development under agreements with allied countries, especially in areas where . Canadian skills and resources are a valuable asset to the project.

The accessibility of information on new development in allied countries is much more assured and more extensive if there exist Canadian programs relating to such developments.

(c) The Improvement of Existing Equipment

Because of the high cost of new equipment, or the inadequacy of existing equipment it is often necessary to make existing equipment more effective by modification.

(d) Participation in Equipment Improvement Being Undertaken Elsewhere

Where equipment in Canadian use or which is contemplated for Canadian use is proposed for improvement in allied countries, a program of development assistance in Canada may be desirable.

(e) Evaluation of New Processes or Equipment

When information of new processes or new equipment becomes available, the question often arises as to whether or not such innovations may be turned to Canadian military use, and if so, whether or not further development will be required. This question can sometimes only be resolved by Canadian test and evaluation.

(f) Technical Investigations Relating to Future Systems and Equipment

In order to be able to make the best selection of weapons and weapon systems and because of the present and increasingly great complexity of such equipments, theoretical studies and experimental investigations need to be made in various technical areas both for their value and in order to keep up to date on the state-of-the-art.

RISK IN DEVELOPMENT MINIMIZED BY TECHNICAL FEASIBILITY STUDIES

7. Where development projects involve only well-known and well-proven technology the element of risk incurred in meeting the required specifications should be small. However, modern military equipment is generally developed to meet specifications which strain at the very limits of the state-of-the-art involved. In such programs, success cannot be guaranteed and inevitably projects will occasionally have to be abandoned after having been carried to a considerable distance when it becomes clear either that the most advanced technology is still not adequate to enable the specifications to be met or else they can be met only at a prohibitive cost. In order to reduce the risk element as much as possible, all development proposals expected to involve significant cost should be:

(a) subjected, before initiation, to adequate studies of technical feasibility to determine whether there are any aspects of the development which may be beyond the limits of existing technology, or for which insufficient data is available for engineering design without applied research being conducted;

(b) kept under continuous review after initiation to assure orderly progress and early anticipation of actions which may be required;

(c) subjected to cost effectiveness studies where applicable to determine if expected costs of development and procurement will justify the anticipated improved results.

8. The studies and reviews need to be done expeditiously since all delays that are imposed only serve to increase the element of risk.

ECONOMIC CONSIDERATIONS

9. Although the primary purpose of DND Development is to meet Canadian military requirements, it is seldom that a development project does not also contribute to broader Canadian economic objectives. Such economic impact needs to be taken fully into consideration in the justification of the overall level of defence development program and major new development projects.

ANNEX G

SUPPORT OF CANADIAN FORCES DEVELOPMENT PROJECTS BY DRB ESTABLISHMENTS

DRB laboratories are involved to a varying extent in projects in the Canadian Forces Development Program. A few projects are conducted entirely within a DRB establishment with the Forces input limited to statement of the requirement, provision of funds for materials, equipment and special facilities and assessment of the results against the requirement. There is however a larger number of projects in which individual scientists or scientific teams at specific establishments are involved as consultants, in assisting the Forces in monitoring a project being conducted by contract or in undertaking a portion of a larger project.

Appendix I provides a list of projects in which DRB establishments are involved together with an indication of the general area of activity and the degree of DRB participation. Not listed in the appendix are the projects under the general heading of Operational Research. In this area, the Defence Research Analysis Establishment, (DRAE) has assigned one of its two major divisions to the task of supplying operational analysis assistance directly to the operational staff. In this case, as distinct from projects aimed at hardware development, the major effort is applied by DRB scientists and officers of the Canadian Forces; the assistance and consultative services may be supplied by commercial contractors.

APPENDIX 1 - ANNEX G

PROJECT TITLE	TECHNICAL FIELDS	DRB PARTICIPATION
ASW Hydrofoil Ship	Ships	The concept of using hydrofoil ships in an ASW role was generated by DRB scientists in co-operation with the Forces. DRB establishments have been active in concept evaluation with a one quarter scale model (DREA), analytical studies of the effectiveness in ASW (CARDE) and in metallurgical and corrosion problems (DREP). DREA will be involved to a considerable degree in providing engineering and analytical assistance in forthcoming ship trials.
Investigation and Tests of Engineering Materials	Ships, Aircraft, Land Vehicles and Armament	DREP and DREA have participated in the past - largely on corrosion problems related to shipbuilding materials.
Blast and Shock Tests of Ships and their Structures	Ships	Models of ship components and full scale structures are subjected to shock tube tests and blast tests at DRES. Scientists from that establishment have also been used in a consultative capacity on underwater shock tests.
Investigation of Non-destructive Methods of Boiler Examination	Ships	This project has been completed at DREP. By means of the system developed, the time required for a complete boiler examination has been reduced to one third.

PROJECT TITLE	TECHNICAL FIELDS	DRB PARTICIPATION
Miscellaneous Aircraft Projects	Aircraft	Use of a control device for battery charging, developed by DCBRE, is one instance of the involvement of a DRB establishment in this many-sided project aimed at the general improvement of aircraft systems.
Torpedo Propulsion Batteries	Weapons and Armament	DCBRE has acquired an international reputation as a centre of expertise on batteries and electrical power sources. The Establishment has conducted a great deal of work over the past 10 years on various types of torpedo batteries. Establishment scientists are consulted on the acquisition of batteries from commercial sources.
Weapons and Ammunition Projects		Several projects involving study, experimentation and development in the general field of ammunition are being conducted at CARDE on behalf of the Forces. In addition, CARDE scientists are involved in consulting roles on other projects in this field.
Communications Projects		Of a total of eight current projects on military communications, DRTE is actively participating in the conduct and management of three and is employed in a consultative capacity on one other.

PROJECT TITLE	TECHNICAL FIELDS	DRB PARTICIPATION
Electronic Warfare Projects	Target Detection and Electronic Warfare	A number of investigations have been conducted by DRTE on the vulnerability of communications systems to jamming, on radio direction finding and related work.
Anti-Submarine Warfare Projects	Target Detection and Electronic Warfare	DREA, DREP, DRTE and, to a lesser extent, CARDE are involved in a variety of projects concerned with underwater sound propagation and reception, signal processing, under-water equipment and target localization.
Stabilized Horizon Reference Bar	Navigation	DRTE serves as a consultant on the development of this device which will assist in the approach and landing of helicopters on destroyer escort ships.
Clothing, Textiles and Equipment for the Protection of Personnel	General Equipment	DCBRE provides consulting services and has devised some fabrics and tests for fabrics used in personal equipment. Face masks and chemical and radiation detection devices have received particular attention and in some cases, equipment designed and developed by DCBRE is in use or under trial in the Canadian and allied forces.

ANNEX H

PARTICIPATION BY THE CANADIAN FORCES IN THE DOI DEFENCE EXPORT DEVELOPMENT PROGRAM

INTRODUCTION

In addition to the defence research and development carried out by the DRB and by the Forces themselves, there is a large amount of development effort being applied by Canadian industry under the Defence Export Development program of the Department of Industry. The Department of National Defence provides a significant level of support to this program.

PROGRAM CONTROL

Oversight of the program, including approval of individual project submissions, is maintained by an interdepartmental committee on which DND is represented by the Assistant Deputy Minister (Logistics) and DRB by the Deputy Chairman (Scientific). Supporting the committee are three advisory groups in the general fields of electronics, aeronautics and weapons. These groups have Canadian Forces officers as full-time members and are able to call upon the services of specialist officers as required. Project Review Groups are set up for the monitoring of some of the more complex projects in the program, these too, contain representation from DND.

ACTIVE DND PARTICIPATION

In the majority of the projects in the Defence Export Development Program, the DND activity is limited to the levels of participation outlined above. There are a number of projects, however, for which this department has been called upon to provide facilities, personnel, etc. for the test and evaluation phases:

(a) *Extended Life Sonobuoy.* A project undertaken under the Defence Export Development Program in 1964-65 to develop a longer life sonobuoy which, in quantity production would be cheaper than equipment currently in use in Canada and elsewhere. DND provided aircraft, flying time, and performance evaluation facilities during the summer of 1965.

(b) *CL-89 Reconnaissance Drone.* This project covers the development of a cruise missile designed to carry cameras and other sensors over a 60 mile range. The Canadian Forces have participated extensively in trials of this equipment and there has been some DRB participation as well. The project management office at the peak of the trials activity was staffed by a total of 80 people provided by Canada, Britain and West Germany. Of these, Canada provided 35 (including 6 military officers). At present DND is providing 2 LtCol, 2 Majors and 1 Capt. The estimated total cost of the DND participation over a three year period (1962-1965) is $500,000.

JOINT DND/DOI PROJECTS

In addition to the projects noted above where there is DND participation in projects sponsored by DOI, there are projects where sponsorship may be shared between the two departments. The principal example is in the development of the CL-84, Tilt Wing, Aircraft. This Project was sponsored by DOI through development of the first prototype. The phase begun in 1968 will result in the production of three prototype aircraft for the more extensive engineering and flight trials necessary to obtain certification of airworthiness and for assessment against Canadian Forces requirements for V/STOL aircraft.

The possibility of joint sponsorship of other development projects remains open.

GENERAL CONCLUSIONS

The DND contribution to the DOI Defence Export Development Program has been and continues to be an essential part of the program. While some dollar costs have been stated above, it is somewhat impracticable to evaluate the total DND contribution in these terms because detailed cost accounting systems differ or because cost accounting has not, in all cases, been applied by the agencies involved. With the exception of the CL-89 project, there has not been a continuing heavy strain on DND resources and in most cases this department receives value in the form of up-to-date information on new technical developments and is thus enabled to maintain a high level of expertise among the technical personnel involved.

ANNEX I

REGIONAL DISTRIBUTION OF DEVELOPMENT CONTRACTS

TABLE 1 — Breakdown by Industrial Sectors

	FY 65/66	FY 66/67	FY 67/68
	$000's	$000's	$000's
Sector			
Aerospace	12,466	19,455	5,722
Electrical & Electronics	11,172	4,076	5,841
Shipbuilding	339	244	163
Armament & Vehicles	407	563	61
Project Management	N/A	N/A	7,149
General	226	247	109
TOTAL	24,610	24,585	19,045

TABLE 2 — Breakdown by Region

	3 year average for 1965 to 1968
	$000's
Region	
British Columbia	82
Prairies	73
Ontario	17,993
Quebec	4,046
Atlantic	552
TOTAL	22,746

NOTE: It should be emphasized that the figures are based on contract awards and not cash flow and that the figures are heavily influenced by a small number of large awards to major companies.

ANNEX J

PERSONNEL STATISTICS

A. Civilian Officers

Masters Degree Level

Country	Birth	Sec. Ed.	Higher Ed.
Canada	3	3	2
Asia	2	2	-
USA	-	-	3

Years since graduation (average)	13.6
Years employed by DND (average)	10.8
Age (average)	43.0
% Bilingual	0

Bachelors Degree Level

Country	Birth	Sec. Ed.	Higher Ed.
Canada	45	53	53
UK	13	8	7
USA	1	-	2
Europe	3	2	1
Asia	4	3	3

Years since graduation (average)	16.3
Years employed by DND (average)	7.5
Age (average)	50.0
% Bilingual	18.2

Other Professional Qualification

Country	Birth	Sec. Ed.	Higher Ed.
Canada	1	1	1
UK	22	23	23
Australia	1	1	1
Europe	4	4	4
Asia	1	-	-

Years since graduation (average)	22.3
Years employed by DND (average)	12.4
Age (average)	49.2
% Bilingual	17.2

Overall Professional Civilian Statistics

% employed by industry at some time	72.0
% on staff of universities at some time	3.4
% on staff of provincial departments or agencies at some time	3.9
% on staff of other federal agencies at some time	12.0

B. Military Officers

No. of officers considered	308
No. holding degrees or equivalent professional qualifications	202
Years since graduation (average)	12.7
Age (average)	39.3

ANNEX K

EXPENDITURES ON $000's DEVELOPMENT ACTIVITIES

Functions	62/63	63/64	64/65	65/66	66/67	67/68	68/69
Support of R & D in Industry							
(a) Development	10,200	12,500	17,800	30,900	17,500	13,000	16,500
(b) NETE (Note (a))				700	750	800	850
Intramural Costs							
(a) LETE (Note (b))				2,400	2,500	2,600	2,700*
(b) AETE (Note (b))				6,600	6,800	7,200	7,500*
(c) Eng. Sub-Branch (Note (c))				1,200	1,200	1,200	1,200*
				41,800	28,750	24,800	28,750

Note (a) Will continue at a similar level

Note (b) Activities under review

Note (c) Very approximate

All expenditures fall in the Scientific Discipline "Engineering and Technology" and in the Area of Application "War and Defence".

* Estimated.

ANNEX L

REQUIREMENTS DEFINITION AND PROJECT FORMULATION

The processes of Requirements Definition and Project Formulation are the stages which involve the decision as to whether development activity will be initiated. These stages are briefly described in the following paragraphs. A flow diagram illustrating the process is shown in Appendix 1.

REQUIREMENTS DEFINITION

The need for committing a requirement to paper will usually be recognized in staff discussions between the VCDS and CTS Branches. If the technical and cost feasibility of meeting the need is not clear or if there is a clear need for detailed analysis, an Operational Equipment Objective (OEO) will be written. This will contain only a broad statement of military need and impose the minimum constraint upon the study of options. The responsibility for approving OEOs and OERs rests with the VCDS Branch although they must be developed in close consultation with the technical experts of the CTS Branch and the scientists of DRB.

On receipt of an approved OEO from the VCDS, the CTS Branch is responsible for preparing a Technical Approach (TA). The TA describes system options which are operationally, technically and financially feasible; the information relates to the entire system life cycle and it covers trade-off studies of cost versus time and cost versus performance. A good deal of analysis is required and inputs are needed from staff elements throughout CFHQ and DDP.

The first phase of the preparation of a TA involves the identification of the options which warrant further detailed study. One or more of the following options may be identified:

(a) Currently Available Equipment of Known Performance

On the basis of knowledge within CFHQ, it will usually be possible to identify systems or equipment which are currently available and for which adequate cost and performance data are either available or easily obtainable.

(b) Procurement of Available Equipment or Equipment Under Development for Evaluation

In some cases, it will be possible to identify systems or equipment which are available and which may fill the need but for which sufficient cost and performance data are not available to make comparisons with other options. To obtain the necessary performance data, it will be necessary to procure a small number of the equipments and perform engineering and/or user trials.

(c) Initiation of Preliminary Development

If it is apparent that no available system or equipment will meet the need, it may be necessary to consider initiating development activity. At this stage, it will take the form of Preliminary Development and it will be aimed primarily at demonstrating operational and technical feasibility rather than developing hardware for ultimate Service use. It may be confined to analytical studies or it may involve "breadboard" engineering or quite complex engineering models. The principal aim will be to obtain sufficient data to allow adequate cost/effectiveness comparisons with other options and to ensure that the risks are sufficiently small to justify a recommendation for Engineering Development or Acquisition (including Operational Systems Development).

(d) Initiation of Joint Development

It may sometimes be possible to identify at this stage the possibility of development in collaboration with another Government Department or with an allied country with a view to meeting joint requirements.

(e) Initiation of Applied Research

If a survey of the field indicates that no system or equipment is either available or under development and if it is not considered that development can be initiated in Canada without further technological advances, it may be necessary to request DRB or some other agency to initiate applied research to develop new technology.

If options covered only by (a) or (b) above are identified, it will be possible for the CTS to respond to the OEO relatively quickly with details of specific options and cost/effectiveness comparisons. If it is considered that no easily definable options can be identified, the response will also be relatively rapid and indicate that either further consideration will have to be given to the operational concept or that hardware acquisition must await specific advances in technology.

The Preliminary Development may be completed in a short time if only analysis or modest evaluation is required or it may take several years when major hardware activity is involved. When it has been completed, the TA is prepared and particular care is needed to re-investigate progress in other countries during the time required for the Preliminary Development activity. The TA is then used by the VCDS as the basis for the preparation of an OER.

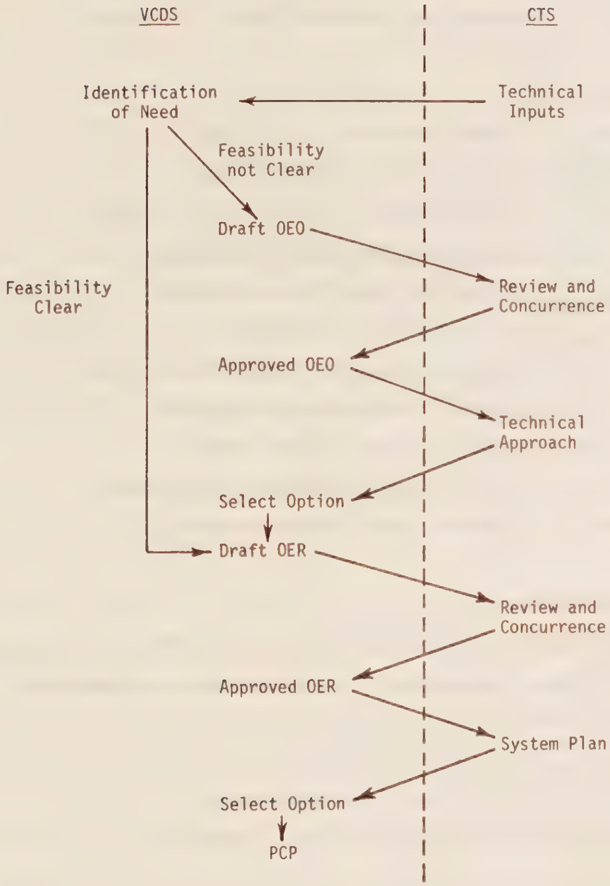
PROJECT FORMULATION

As already stated, OERs are detailed statements of the equipment, facilities, organizations and manpower which constitute operational systems. They do not identify specific pieces of equipment but state the required performance in ranges of acceptable values or performance envelopes. It is important that the Requirements Definition leading to the OER shall have determined that, if development is still required, it will be primarily of an engineering nature (i.e., Engineering Development) and that the necessary technology is available.

The process of Project Formulation leads to the preparation by the CTS Branch of a System Plan (SP) which identifies all the system options which may satisfy the OER and provides sufficient information for a choice to be made. The SP may reject a number of options and may concentrate on one (or a few) feasible options. It contains details of the total cost and resource requirements for system acquisition and life cycle operation so that informed decisions can be made. It covers Engineering Development, production and Operational Systems Development when appropriate.

The material contained in the SP is used by the VCDS Branch to prepare a Program Change Proposal (PCP) which recommends a specific course of action for improving operational capabilities. Approval of the PCP and introduction of the item in the IDP represents the key decision to proceed with the acquisition of equipment and its associated support.

APPENDIX 1 — ANNEX L



ANNEX M

DEVELOPMENT AND ASSOCIATED RESEARCH POLICY GROUP

COMPOSITION

Chairman	- Chief of Technical Services (CTS)
Vice-Chairman	- Deputy Chief Engineering (DCENG)
Members	- Assistant Deputy Minister (Logistics) (ADML)
	- Assistant Deputy Minister (Operations) DDP
	- Deputy Chief Force Development (DCFD)
	- Deputy Chief Plans (DCPLANS)
	- Deputy Chairman (Scientific) DRB (DC(Sc)/DRB)
	- Scientific Assistant to CTS (SA/CTS)
	- Director General Programs (DGPROG)
	- Director General Budget and Finance (DGBF)
Secretary	- Director Project Formulation (DPF)

TERMS OF REFERENCE

1. The Group will be advisory to the Chief of the Defence Staff through the Chief of Technical Services on all matters relating to development and associated research.

2. It will meet at the call of its Chairman to:

(a) review and make recommendations regarding DND policy for development;

(b) examine and approve proposals for new or revised projects or programs for development and/or associated research submitted by the Canadian Forces and the Defence Research Board, for inclusion in the Integrated Defence Program;

(c) provide the basic screening of Development Estimates each year;

(d) formulate directives and procedures for the efficient handling of development and related activities, including a review procedure for continuing programs.

ANNEX N

PROMIS

One of the management "tools" of the Technical Services Branch is a Project Management Information System called PROMIS. The system was devised by a firm of management consultants, Peat, Morwick, Livingston and Company under contract and is intended for application to a much wider range of projects than those included in the Development Program. It has been taken into use only since the beginning of 1968 and is being applied to approximately 30 projects of which only five involve development: the remainder are concerned with the acquisition of major items of defence equipment.

In essence, PROMIS is a reporting system by means of which periodic summary reports on costs and schedules are made available to senior management on the status of major projects. Provision is also made for reporting on request or by exception with the latter action being taken in the event of overruns on slippages. Reports are made to lower levels e.g. Director and Project Managers, as well as to senior management.

Examples of development projects being reported upon under PROMIS are the Hydrofoil Project and the development of the 1¼ ton high mobility truck.

ANNEX O

DEVELOPMENT PROJECTS

Technical Field	Project Title	Project Schedule — Years (62–73)
Ships	ASW Hydrofoil Ship - FHE 400	
	Ship Machinery Design and Improvement	Recurring
	Investigation and Tests of Engineering Materials	Recurring
	Shipboard Electrical Power Systems	
	Quick Securing Device for Helicopters	
	Ship Noise Reduction	Recurring
	Blast and Shock Tests, Ships and their Structures	
	Development of Equipment for Replenishment at Sea	
Aircraft and Aerospace Vehicles	Miscellaneous Aeronautical Studies	Recurring
	CHSS-2 Sea King Modernization	
	Operational Assessment of a Tilt Wing VSTOL Aircraft - CL-84	
	CHSS-2 Ice Protection System	
	Recce/Surveillance Electronic Sensor Package System - CF 5 Aircraft	
	Twin Engine UTT Helicopter	
	Integrated Flight System and Heads Up Display	
	Pressure Altimeter	
	Automatic Landing System and Couplers	
Military Vehicles	Truck Utility, High Mobility 1¼ Ton	
	Minor Engineering Tasks. Vehicle and Mobile Engineering Equipment	Recurring
	Kits for Truck Utility, High Mobility 1¼ Ton	

Technical Field	Project Title	Project Schedule — Years											
		62	63	64	65	66	67	68	69	70	71	72	73
Weapon Systems and Armament	Anti-Submarine Weapon Improvement												
	Minor Engineering Tasks. Ammunition, Mines and Demolition Stores					Recurring							
	Torpedo Propulsion Batteries					Recurring							
	Provision of Armour Plate					Recurring							
	Signal Underwater Sound												
	Short Range Air Defence Weapon System												
	High Performance .50 in. cal AP Ammo												
	Smoke Generators and Markers												
	Minor Engineering Tasks. Ground Environmental Weapon Systems					Recurring							
Communications	Miniature Tape Recorder - Reproducer												
	Improvement of VHF/UHF Communication												
	Antenna Model Studies					Recurring							
	Position Indicating Message System												
	Analysis and Abatement of Radio Frequency Noise and Interference					Recurring							
	Improvements to RCN Communications												
	Project MALLARD												
	Tactical Satellite Communication Program					Recurring							
	MF/HF Common Antenna												

Technical Field	Project Title	Project Schedule — Years 62	63	64	65	66	67	68	69	70	71	72	73
Target Detection and Electronic Warfare	Sound Absorbent Material Studies												
	Transducer Array Studies												
	ASW Area Surveillance												
	Airborne ASW Data Reduction and Classification Equipment												
	Magnetic Anomaly Detection					Recurring							
	Shipborne Radar Performance Monitoring Equipment												
	Vulnerability of Spread Spectrum Communication Systems to ECM												
	Engineering Studies and Investigations of ASW Detection and Localization Systems					Recurring							
	Sonar Signal Processing												
	Miniaturized Sonobuoy												
	Feasibility of a Ground Scatter Jammer												
	Shipborne Passive Surveillance System												
	Sonobuoy Communication Improvements												
	VDS Tow Cable Development												
	Shipborne ECM Antenna Development												
	Radar Illumination Detector												
	Sonar AN/SQS 505 Development												
	Search Sonar AN/SQS 505												
	Airborne Classification of Sonar Signals												
	Shipboard ASW Computer Programming Studies					Recurring							
	Miscellaneous Underwater Equipment Studies					Recurring							

Technical Field	Project Title	Project Schedule — Years											
		62	63	64	65	66	67	68	69	70	71	72	73
Target Detection and Electronic Warfare (Cont'd)	ABCA Sound Ranging System												
	High Frequency Direction Finding												
	Development of a 0.001 Gamma Magnetometer System												
	Sonar Studies Phase II												
Navigation	Moving Map Devices												
	Navaid Target Computer												
	Stabilized Horizon Bar												
Electronics and Electrical Equipment	Electronic Research and Development Committee					Recurring							
	Engineering Tasks Associated with Improvement of Electrical and Electronic Equipment					Recurring							
	Electrical Power Supplies for Aerospace Support												
Training Equipment	Tutor Operational Flight Trainer												

Technical Field	Project Title	Project Schedule — Years											
		62	63	64	65	66	67	68	69	70	71	72	73
Equipment	Clothing Textile and Personal Equipment					Recurring							
General	Institute of Aviation Medicine Projects					Recurring							
	C and B Warfare Defence Equipment					Recurring							
	Nuclear Warfare Defensive Equipment					Recurring							
	Photographic Equipment Development					Recurring							
	Tech. Investigations of Materials, Supplies Packaging Procedures and Food					Recurring							
	Minor Engineering Tasks. Miscellaneous Field Equipment					Recurring							
	General Stores					Recurring							
	Integrated Walking Out Dress												
	Life Support Projects					Recurring							
	Supersonic Tumbling Aerofoil												

Technical Field	Project Title	Project Schedule — Years (62–73)
Operational Research Studies	Automation of War Games	
	Combat Intelligence System Studies	
	Studies of Land Operations in Limited Visibility	
	System Requirements for Tactical Air Operations	
	Miscellaneous Analysis	Recurring
	Terrain & Intervisibility Analysis	Recurring
	Composition of Future Maritime Forces	Recurring
	Arctic Investigations	
	Computer Model for the Analysis of Transportation Support Mobile Forces	
	Field Force Logistics Study	
	Computer Rental for OR Investigations	Recurring
	Requirements for Aids to Amphibians	
	Study of Tactical Automatic Data Processing Systems for Land Forces	
Miscellaneous	Provision of Test Laboratory Material Equipment	Recurring
	Ships' Reliability Studies	Recurring
	Modernization of NRC Navigation Instrument Laboratory	
	Feasibility & Project Definition Studies	Recurring
	Procurement & Evaluation of Available Equipment	Recurring
	Miscellaneous Projects for ASW Special Project Unit	Recurring

Technical Field	Project Title	Project Schedule — Years											
		62	63	64	65	66	67	68	69	70	71	72	73
Miscellaneous	Project Initiation					Recurring							
(Cont'd)	Freight & Custom Charges					Recurring							
	Re-equipment of Primrose Lake Evaluation Range												
	Air Evaluation Facilities Equipment Program					Recurring							

ANNEX P

NAVIGATION SET, LAND, VEHICULAR (NAVAID)

The primary objective of the project was to develop a self contained device to assist tank commanders to guide their vehicles in conditions of darkness or poor visibility. The scope was subsequently broadened to include guidance of other vehicles and to provide a means of rapid and accurate position reporting.

The project was initiated more than 10 years ago and the first experimental models were produced in 1958 and evaluated by the Armoured Corps School. On the basis of this evaluation, models for user trials were produced and evaluated under more stringent training conditions by a field unit. In the early 1960's approval was given for the production and issue of the NAVAID to all field units and subsequently, models were loaned to other nations under the ABCA Standardization agreement. The system is now being produced in Canada for use by British and US Forces.

Development costs of the project were approximately $170,000 including costs of the user trial models. The project has resulted in procurement for the Canadian Forces to a value of just under $2.0 million.

No major difficulties were encountered during the course of the development and the project is generally considered as being completely successful.

ANNEX Q

ANTI PERSONNEL MINE DEVELOPMENT

The initial objective of this project was the development of a family of mines for the Canadian Army. However, with the change in the Canadian Army structure it was subsequently decided to proceed only with the Anti Personnel type and the associated practice and drill versions.

The project which was initiated in 1953 was based on a British War Office Specification. The first models for engineering and user trials were available about 2 years later. The success of these trials resulted in requests from the US, UK and West Germany for quantities to evaluate the performance against their military requirements. The mine successfully passed all the acceptance trials and has now been standardized in Canada, US, UK and West Germany.

The development cost for the "live" mine (designated C3) was $67,500.00 while that for the practice and drill versions was $15,000.00 giving a total project cost of $82,500.00. To date, procurement for the Canadian Armed Forces has amounted to approximately $125,000.00.

Foreign sales have thus far been confined to the UK and amount to a value of approximately $1.6 million; negotiations for an additional purchase are now underway.

No major difficulties were encountered during the development of these mines. This type of store required extensive environmental test programs to prove the operational and safety features; this accounts for the relatively slow progress. All development was terminated in 1964.

ANNEX R

SUPPORT KIT OVERHEAD PROTECTION (SKOP)

The primary objective of the project was to develop a 2-man trench shelter kit which would not weigh more than 2 pounds and would not degrade the soldiers combat effectiveness. This item was to replace the 180 pounds of revetment material and equipment previously required to achieve the same purpose.

Initial studies were commenced in 1955 and by 1961 the concept developed was adapted by both the Canadian Army and the ABC group. Further development resulted in the item being accepted for operational use by the Canadian Army in 1963 and in 1964 a contract for 14,000 SKOP kits was awarded. However, the UK who had access to reports of the Canadian concept and, by applying greater development effort, were able to overtake the Canadian development; by 1964 they had produced a Kit, Individual, Protection (KIP) which was adopted by the Australian Army in 1965.

Development costs for SKOP were approximately $67,000 and the procurement contract for 14,000 kits for the Canadian Army was approximately $100,000. (It should be noted that it was originally planned to purchase 100,000 kits at an estimated cost of $500,000). The current situation is that Belgium, West Germany and the US have acquired small quantities of SKOP for evaluation purposes and inquiries have been received from Denmark and Israel.

The degree of technical success achieved by this project is demonstrated by the level of interest displayed by the NATO countries and in particular by the UK who were able to develop the concept into a marketable item and go to production with KIP prior to the actual Canadian production of SKOP.

It would appear that the difficulties encountered in successfully producing a marketable product could be attributed to the lack of a definite policy on field defences which resulted in delays in the acceptance of the concept. Although there is a current product improvement project for SKOP, staff shortages since 1965 have slowed work on this project.

A N N E X S

THE BEARTRAP — HAULDOWN
RAPID SECURE AND MOVING SYSTEM FOR HELICOPTERS

In anti-submarine operations in the Canadian Forces, the area of effectiveness of our ships has been greatly enhanced by the addition of helicopters to the fleet. Problems arose however, in the handling of these helicopters in preparation for take-off or in landing due to the smaller size of the landing area on destroyers and the relatively greater degree of motion of the small ship, than would be the case in operations based on an aircraft carrier such as the Bonaventure. To overcome these difficulties, a project was initiated in the late 1950's with the objective of the development of a device for securing a helicopter to the landing platform immediately upon touching down and including a means of moving the helicopter from the point of touchdown into the hangar, (or in the reverse direction in preparation for take-off), with the helicopter restrained from sliding and toppling.

Since statement of the objective in July 1958, the objective itself has not been changed. However, the system required to attain it has evolved during the course of the development.

The program began with a study of basic schemes and the initiation of a design competition in Canadian Industry. This competition was won by Fairey Aviation of Canada and a contract was awarded for the construction of a prototype "beartrap" and matching helicopter probe assembly. At about the same time, trials were conducted at the Sikorsky Aircraft Company to prove compatibility of the CHSS-2 "Sea King" helicopter with the haul-down technique. In early 1963 sub contracts for the haul-down winches and traverse assembly were awarded to Dowty Equipment Limited and assistance in design of the control system was obtained from the National Aeronautical Establishment of NRC. In late 1963, the prototype equipment was installed in HMCS *Assinaboine* then undergoing conversion on the West Coast. Flying trials and other trials of the system were commenced and, despite a number of difficulties which might have been expected with such a completely new concept, the system concept was successfully proven

by the late summer of 1964. Refinements in design found to be necessary as a result of trials of the prototype system were incorporated in the designs for production and contracts were let in the fall of 1964 for beartrap and winch systems for eight additional ships.

Trials continued with production equipment and with modifications and additional equipment to cater for night time and rough weather operation. By the end of 1967, all trials were considered as complete and the system proven for full operational use.

The development cycle for the "beartrap" system might appear at first glance, to be unduly long (nearly ten years). This is not the case, however, when the complexity of the task is considered. Many development projects are adaptations, major modifications, design refinements, etc. of existing systems or techniques but in this case, a new concept i.e. an invention, had to be devised, produced and made to work reliably in adverse conditions. All of these challenges have been met successfully.

The total cost of development and prototype procurement was $700,000.00. The total cost for the 9 ship sets for the 205/265 classes was $1,832,000.00. The cost estimate for the 4 ship sets for the DDH 280 class is $2,060,000.00.

Up to the present time the USN, the US coast guard and the Japanese Defence Forces have bought one system each for evaluation purposes. As well, the West German Navy has also procured two systems for a smaller helicopter. It is hoped that large foreign orders will result.

A N N E X T

RADAR SET AN/MPQ-501

(Counter Mortar Radar)

The original objective of this Project was to develop a K-Band radar capable of detecting a mortar bomb in flight with a view to extrapolating from the information so obtained in order to deduce the location of the mortar which fired the bomb.

The basic aim remained unaltered throughout the life of the project but at an early stage, the decision was taken that every effort should be made to keep abreast of progress in technology as well as changes in military requirements by incorporating in successive model changes which resulted from a product improvement program being conducted simultaneously by NRC. Thus, for example; the original model operated on a wavelength of 1.25 cm whereas subsequent models operated at 1.87 cm; a polarizer was added to later models to improve performance in rain; and, a number of configurations were produced which permitted mounting and operation on a Bren Gun Carrier, a 2½ ton truck, a British Saracen armoured personnel carrier (APC), a Canadian Bobcat APC, the US M113 APC and finally, the US M113A1 APC.

Development commenced soon after World War II with experimentation, design and fabrication by the National Research Council of a model operating at a wave length of 1.25 cm and capable of being mounted on a Bren Gun Carrier. This was followed in 1951 by a model operating from a Saracen Armoured Car which was subjected to limited user trials. Subsequent production prototypes were built at Canadian Arsenals and given more extensive user trials in the late 1950's. Production was started in 1961 and models have been procured by Germany and Italy for purposes of evaluation.

The length of the development cycle was the result of a combination of factors, the most significant being the loss of expertise and production facilities which followed the cessation of radar set production at Canadian Arsenals Limited.

The AN/MPQ-501 Radar is now in service with the Canadian Forces. It materially exceeds the stated military requirements it was built to satisfy and is the only such radar in the world today which incorporates an effective polarizer to permit operation in rain, snow and fog. In these respects it is significantly more effective than its US and British counterparts.

The total direct cost for development and the production of twelve equipments was approximately $5,333,000.00. This total does not include costs incurred for field and demonstration trials or for the support received from Government Agencies other than NRC.

Two AN/MPQ-501 radars were sold; one each to Germany and Italy. These were subjected to trials and were well received by the military staffs. The DND contribution to the sales effort included demonstrations, maintenance support and the training of officers, operators and maintenance personnel in Canadian Army Schools.

The AN/MPQ-501 Counter Mortar Radar development has now been terminated in conjunction with the introduction into service of the equipment. In the light of significant changes in state-of-the-art and military requirements, no further development is planned in this area.

ANNEX U

MARCONI DOPPLER RADAR PROJECT

In response to an RCAF requirement for a more accurate, dead reckoning navigation system a joint RCAF/DRB project was initiated in 1952 with the objective of development of a light weight aircraft navigation system which would automatically measure aircraft ground speed and drift angle. In the original concept it was intended that the system should be developed especially for the CF-100 aircraft; this aim was later broadened to include, Maritime Patrol, Transport, and more advanced interceptor aircraft as well.

At the outset, two approaches were taken with DRB investigating new concepts and the Canadian Marconi Company under an RCAF Development contract, investigating improvements to systems developed elsewhere. Broadening of the scope of the project brought about some re-direction and by 1956, Canadian Marconi had succeeded in producing a dual antenna system, incorporating a Frequency Modulation technique which constituted a major technical breakthrough. Prototypes were flight tested over the next two years and procurement for service use commenced in 1958.

The project is considered as completely successful in that all objectives were attained and the military requirements satisfied. Development costs were slightly under $1,000,000.00 and procurement for the Canadian Forces totaled approximately $12,000,000.00.

Following on from the successful development sponsored by the Canadian Forces, the company was granted further development assistance under the Defence Export Development Program of the Department of Industry. This assistance costing approximately $5,000,000.00 resulted in foreign sales of the Marconi Doppler Radar totalling $130,000,000.00.

ANNEX V

EXPENDITURES ON TESTING AND STANDARDIZATION ACTIVITIES

$000's

Function	63/64	64/65	65/66	66/67	67/68 Note (a)	68/69
Quality Assurance Division						
(a) Personnel	6,486	6,224	6,655	6,799	7,331	7,052
(b) Other O & M	652	640	651	589	645	988
(c) Capital	191	190	228	198	158	835
TOTAL	7,337	7,054	7,334	7,566	8,134	8,875
CAMESA						
(a) Personnel	267	278	290	306	275	286
(b) Other O & M	580	497	572	391	156	26
TOTAL	847	775	862	697	431	312
DESS						
(a) Personnel	—	128	131	136	140	144
GRAND TOTAL	8,184	7,957	8,327	8,399	8,705	9,331

(a) Responsibility for the CAMESA laboratories was transferred to QAB in 67/68.

ANNEX W

SUPPORTING DATA ON CAMESA

FUNCTIONS

The present role of CAMESA is to provide a service to the Canadian Forces in support of procurement and maintenance of electronic equipment and material. This service involves the following basic functions:

(a) Applications Engineering.

(b) Document Provisioning.

(c) Qualification Approval Management.

(d) Reliability Assessment.

(e) Laboratory Program Management.

(a) Applications Engineering

As part of the application engineering function CAMESA provides advice and makes recommendations to the Canadian Forces Design Authorities, concerning the application of electronic parts in military equipment. This frequently involves the evaluation and assessment of non-standard items which have been proposed for use in specific military equipment, the screening of procurement lists and the investigation of field failures. As a back-up for this function CAMESA has a library of approximately 10,000 test reports resulting from CAMESA "in-house" test programmes, and in addition has available 25,000 microfilm reports provided through the Inter-Agency Data Exchange Programme (IDEP). In the event that the screening of existing technical data does not provide the necessary assurance that the part under consideration is suitable for the intended application; CAMESA has at its disposal a test laboratory capable of performing any type of performance or environmental test which would be appropriate for the particular circumstance.

(b) Document Provisioning

CAMESA is responsible for writing, coordinating, and promulgating specifications and associated documents which are used for the procurement of electronic parts and associated materials and electrical items required by the Canadian Forces. Currently, CAMESA administers approximately 4,000 individual

documents in this category. For a number of years, it has been the Department of National Defence policy to use United States "Mil" Specifications wherever possible to satisfy Canadian Military requirements. CAMESA prepares documents only in those areas where US Military documents do not exist or where they are unsuitable for Canadian Defence needs. This policy is considered reasonable in view of the close similarity between the defence requirements of the two countries. To facilitate the use of US prepared "Mil" Specifications in Canada, CAMESA has issued a support document identified as JCNAAF-A-222 which defines the administrative procedures for the use of these documents in Canada. In addition, CAMESA has established an extensive coordination programme with the Canadian Forces, Canadian Industry and the US Specification Development Agencies. This coordination programme is designed to keep the Canadian Forces and the Canadian Industry informed of changes being made to military documents and to provide them with an opportunity to participate in the development of the documents. In addition to providing procurement specifications, CAMESA is responsible for standardization and has published preferred parts lists as a guide for the selection of items in an attempt to reduce military logistic support requirements.

(c) Qualification Approval Management

Most military procurement specifications for electronic parts require the prospective supplier to obtain Qualification Approval for his product in advance of and independent of any procurement action. Qualification Approval is a design approval only and does not assure the quantity of the product coming from the production line. The quality of the product from production is controlled by acceptance inspection procedures which are also defined in most military specifications. CAMESA is responsible for the management of the Qualification Approval programme. Under present policy qualification testing may be performed at one of three types of laboratories which have been previously approved by CAMESA:

(a) a manufacturers "in-plant" laboratory;

(b) an independent commercial laboratory;

(c) a government laboratory.

For some time, the trend has been towards maximum utilization of the "in-plant" laboratory. While there are direct economic advantages to DND when the qualification tests are performed at the applicant's expense, the chief reason for introducing this policy was technical rather than economic. It is believed that manufacturers of electronic parts who possess an "in-house" qualification testing capability will be in an inherently better position to provide the Canadian Forces with high quality items than are those manufacturers who are unable to perform their own development and control tests on their product. It is also believed that this "in-house" testing capability is significant in enhancing a manufacturers potential to participate in the export market where the demonstration of performance is being demanded to a greater and greater extent. Currently, there are 35 "in-plant" laboratories approved for performing tests to 50 different specifications. The qualified products list resulting from the qualification programme covers approximately 125 component classes with 12,000 individual listings. In conjunction with the national qualification programme, CAMESA administers the US-Canada agreement for reciprocal acknowledgement of qualification approval and a similar agreement with other NATO countries.

(d) Reliability Assessment

In the area of reliability, CAMESA coordinates and promulgates documents which are required in support of the electronic parts programme. Until recently, CAMESA operated a very sophisticated testing programme related to the establishment of quantitive reliability requirements for electronic parts. Work on this test programme has been suspended.

(e) Laboratory Programme Management

A comprehensive laboratory testing capability is required to support the CAMESA programme. This laboratory support has been provided to CAMESA by the Ontario Hydro for many years under contract. The contract with the Ontario Hydro has now been discontinued and all CAMESA testing is being performed in a government laboratory operated by the Quality Assurance Branch, of the Department of National Defence. This laboratory is used:

— to perform evaluation tests required in conjunction with the CAMESA application program —

— to perform qualification approval audit tests —

— and to perform qualification tests on specific products exempted from the "in-plant" test program.

CAMESA continues to have the responsibility for the quality and acceptability of all test laboratories utilized for Qualification Approval testing. This involves certification of the testing laboratory and establishment of adequate correlation and calibration requirements.

TERMS OF REFERENCE

See Appendix 1 to this Annex.

FORMAL AGREEMENTS

CAMESA is involved in two formal agreements with the USA:

(a) "US/Canada agreement for Qualification of Products of Non-Resident Manufacturers" details of which have been issued in DOD instruction 2045.2 dated 23 April, 1968; and

(b) the involvement of CAMESA in US/Canada defence economic co-operation is recognized by the following quotation from the US Defence Standardization manual 4120-3M: "The Canadian Military Electronics Standardization Agency (CAMESA) will be furnished in consonance with DOD Directive 2035.1" Defence Economic Co-operation with Canada drafts of all standardization documents being co-ordinated with the FSC classes identified in the appendix to DOD instruction 2045.2.

CO-OPERATIVE ACTIVITIES

CAMESA provides a wide range of advice to other agencies and departments in Canada including:

(a) advice to DDP on procurement sources;

(b) advice to DOI on Government-funded industrial support activities;

(c) advice to DOT on electronic parts;

(d) co-operation with NRC in exchanging data, test equipment calibration and investigations; and

(e) extensive co-operation with the Quality Assurance Division;

(f) participation in committees of the Canadian Government Specification Board; and

(g) membership on DRB advisory committees.

The Agency works closely with industry in developing specifications, the implementation of product qualification programs and in the application of components in military equipment. It also co-operates with the Electronics Industries Association.

On the international scene, the Agency works closely with various agencies in the USA including the Defence Electronics Supply Centre and also participates in the activities of the International Electro-Technical Commission and its sub-committees. In addition it is involved in supporting various activities associated with international agreements such as NATO, the ABCA Standardization Agreement and the Air Standardization Co-ordinating Committee.

APPENDIX 1 — ANNEX W

TERMS OF REFERENCE

CAMESA

CAMESA is responsible to DGCES for:

1. The application, testing, qualification and documentation of parts, materials and associated assemblies for DND, other government departments and industry. (Note 1)

2. Plans, policies and procedures governing qualification, applications, documentation and testing of parts, materials and associated assemblies. (Note 1)

3. Activities pertaining to the application, testing, qualification and documentation of parts, materials and associated assemblies: (Note 1)
   (a) Specifications and Standardization Documents.

   (b) Engineering data and drawings.

   (c) Qualification approval of Canadian and Foreign products.

   (d) Qualified Products Lists and Lists of Preferred Parts.

   (e) Qualification testing laboratories and guidance on testing techniques.

   (f) Test programs in government and industrial laboratories on standard and non-standard parts and materials.

   (g) Test methods, procedures, calibration and correlation.

   (h) Financial and budget requirements for laboratory operations.

   (i) Manufacturers production facilities and processes.

   (j) Parts application engineering and investigation of field failures.

CAMESA is responsible to DGCES for:

(k) Assistance to CDF, procurement agencies and industry in interpretation of documents and determining qualified sources of supply.

(l) International agreements and standards.

(m) Representing DND, and liaison with CDF, Canadian/Foreign government departments and international groups on international standardization.

(n) Reliability and quality assurance.

(o) Data bank for parts, processes and reliability; Canadian participation in the Interagency Data Exchange Program.

4. Future standardization and testing activities in support of CDF requirements. (Note 1)

NOTE 1: Pertaining to all communication and electronic equipment.

ANNEX X

SUPPORTING DATA ON QAB

FUNCTIONS

A block diagram of the organization is reproduced in Appendix 1 and the following paragraphs describe the functions of the three divisions.

Quality Assurance Engineering Division

The primary function of the Quality Assurance Engineering Division is to initiate and maintain such regulatory action as is necessary to ensure the conduct of adequate, efficient and effective quality assurance surveillance and verification of the production of all types of defence materiel offered in satisfaction of contracts placed either within or outside Canada. This involves:

— developing, producing and promulgating the operating procedures necessary to guide quality assurance field staffs;

— carrying out liaison to promote the quality assurance concept with Design, Requisitioning and Purchasing Authorities to ensure that their procedures and practices are adjusted if necessary to be consistent with quality assurance implementation requirements;

— providing the engineering capability necessary to ensure effective and continuous communication between Quality Assurance Branch and

(a) the Technical Branch of the Services,

(b) the Department of Defence Production,

(c) the Canadian Government Supply Service,

(d) other government departments requesting services,

(e) the Canadian Commercial Corporation,

(f) NATO Governments with which there are reciprocal agreements;

— auditing the quality control operations of approved contractors and the quality assurance operations of the field organization.

Quality Assurance Laboratories Division

The Quality Assurance Laboratories test and evaluate goods and services for the Canadian Forces. The staff also may be consulted for advice and assistance on related matters. This organization combines the activities of the former Air Materiel Command Materiel Laboratory, Inspection Services Laboratory complex, and the laboratory previously operated by Ontario Hydro for the Canadian Military Electronic Standards Agency (CAMESA). While quality assurance activities and flight safety investigations predominate, the laboratories accept essential projects of design, development, procurement, storage and use of defence materiel. Principal activities include test methods development for specifications and standards; prototype evaluation in support of product improvement and development; qualification approval of a product, firm, facility, personnel or standards; production testing of goods for acceptance; failure and complaint investigation; flight safety, providing specialized testing services through the Central Electronics Component Inspection Laboratory (CECIL) program in support of Canadian industry; maintaining the departmental physical reference standards for such fields as electronics, electricity, metrology and radiation; calibration of equipment with traceability to national standards; correlation of test methods, techniques, procedures, work processes, equipment or test results; and investigational testing in support of training, health and safety programmes.

Quality Assurance Support Services Division

The Quality Assurance Support Services Division provides essential specialized administrative and technical quality assurance support services to the Quality Assurance Branch Headquarters, the Quality Assurance Laboratories and the field units. These services cater for the following:

(a) Quality assurance proofing and testing services at the Proof Ranges, Nicolet, Quebec, for all types of weapons and projectiles coming into service from manufacturers and other suppliers and for the provision of quality assurance reproofing and retesting services as requested for the Canadian Armed Forces.

(b) Planning, developing and giving direction to the Single Supply Point which is the integrated unit responsible for storing, reproducing and

distributing technical data produced or authorized by the Design Authorities and which is required for tendering purposes, manufacturer's guidance, reference purposes and governing of quality assurance.

(c) Provision of specialized quality assurance training within Materiel Command.

(d) Responsible for providing at Quality Assurance Branch Headquarters and across Canada:

(i) Personnel, pay and allowance services.

(ii) Supply, storage and self-accounting services.

(iii) Financial services.

TERMS OF REFERENCE

See Appendix 2 to this Annex.

FORMAL AGREEMENTS

QAB is involved in the following formal agreements with other Agencies/Departments in Canada, and internationally:

(a) NATO — Military Agency for Standardization (STANAG 4107- Mutual Acceptance of Government Quality Assurance).

(b) DDP — Steering Committees (most major projects).

(c) Trade Associations (such as Canadian Packaging Associations, Air Industries, Tea and Coffee Association).

(d) Co-operative Regulatory arrangements with:

(i) Department of National Health and Welfare (Pharmaceutical).

(ii) Department of Agriculture (Food and Drug Inspectorate).

(e) Department of Energy, Mines and Resources — Metrographic and wet Chemical analysis.

(f) Reciprocal Inspection Agreements.

The Branch is also involved in certification, verification, calibration and surveillance on behalf of the US Defence Department (Ordnance) on gauges and equipment used to inspect components manufactured in Canada for the US Department of Defence. Plants visited by the calibration team include Canadian Flight Equipment in Trenton, Bata Engineering in Batana, General Impact Extrusion Toronto and many others.

CO-OPERATIVE ACTIVITIES

Appendix 3 to this Annex contains a list of activities undertaken in co-operation with other departments and agencies and with other countries.

QAB PROJECTS AND INVESTIGATIONS

The following examples indicate the nature of the activities of the QAB:

(a) Flight Safety Investigations

(i) Lightbulb Analysis as an Aid in Accident Investigations. Two types of light bulbs found in aircraft warning light systems were tested to determine if their filament profiles are characteristic of whether they were on or off when they receive a severe shock such as in an aircraft crash. All of the bulbs were submitted to a spectrum of tests covering eight "in-service" factors which affect the condition of a bulb and its filament. Subsequently the bulbs were sectioned using techniques developed during the test program and photographs of the bulbs tested were taken under projection microscopes. These results were then applied to examine light bulbs removed from a crashed aircraft in order to illustrate the potential of light bulbs analysis in aircraft accident investigation. The report has been widely circulated internationally and the principle has received good acceptance by those interested in flight accident investigations.

(ii) Detailed laboratory examination of the debris from an aircraft crash revealed a possible metal fatigue fracture in one jet engine inlet guide vane which, if it failed in flight, could be ingested into the engine and result in catastrophic failure of the engine

and loss of the single engined aircraft and, as well, the possible loss of the pilot. An investigative program was established with flight safety and logistics staff to determine the prevalence of metal fatigue, guidelines for continual use of the inlet guide vanes in service and improved inspection criteria for new production blades. Very substantial urgency was brought to bear on the program when operational staffs decided that the aircraft fleet must be grounded until inspection could establish that they were safe to fly. An early solution through comprehensive metallurgical analysis and devising inspection techniques for field inspectors to use allowed the aircraft to resume flying with a high level of confidence that blades left in service would not propagate accidents.

(iii) The Directorate of Flight Safety required a technique which would indicate whether bird ingress was a primary cause factor in aircraft accidents generated by suspected power plant failure. The Laboratories undertook the investigation which involved researching work done by others, detailed examination of the engines of a number of crashes, establishing contact and holding consultation with specialists in ornithology and biology. The investigation culminated in the establishment of an analysis technique accomplished through retrieving ash or scrapings off the internal surfaces of the engines which were analyzed for their amino-acid content thereby revealing whether they were animal in nature.

(b) Electronic and Electrical Investigations

(i) Evaluation tests on a shipborne gyrocompass system. Techniques were developed and incorporated into specifications, for magnetic field tests; engineering advice was provided which enabled radio frequency interference (RFI) specifications to be met and also enabled the company to bid successfully for large contracts in the USA.

(ii) Evaluation tests on Crash Position Indicator/Accident Data Recorder. Engineering advice for the laboratories provided at early meetings resulted in tightening specifications. In addition the use of the CECIL facilities has enabled the manufacturer to redesign and/or modify their equipment to meet the stringent military requirements particularly in the electromagnetic compatibility and environmental fields. This has allowed the manufacturer to expand his engineering and production facilities permitting him to accept contracts from Canadian, American and European defence establishments valued at many millions of dollars.

(iii) Special discharge tests were performed on a pre-production silver-cell high energy torpedo battery to determine if the Canadian designed battery would provide the energy required for propulsion and operation of controls within precise timing under simulated static and dynamic conditions.

(c) New Canadian Forces Uniform

The laboratories have undertaken to test all components of the new Service uniform, (including boots, socks, caps and rainwear, as well as cloth for tunics, trousers and great-coats). This has involved the testing of pre-production samples of many items, as well as acceptance and verification tests on initial contracts.

One important phase of this work has been setting up rigid color standards and tolerances, for cloth and other components of the uniform. This has been accomplished by the use of a reflecting spectrophotemeter which makes it possible to assign numerical values (color coordinates), to standard samples. These standards are then used to control the color of production lots by frequent comparisons carried out with a Color Difference Meter.

(d) Development of Test Methods

(i) The laboratories developed tests for evaluating overhead projectors and employed these tests in comparing many makes and models of projectors for the Design Authority.

(ii) Over a period of 12 years, 148 Test Method Development Projects have been completed by the Chemical Laboratories. Twelve new CGSB test methods in the fields of cleaners, fire-fighting chemicals, medical supplies, protective coatings and pétroleum products have resulted from these projects.

(iii) A paper presented to the ABC Naval Tripartite Fuels and Lubricants Committee (by the laboratories) resulted in a complete revision of ASTM Method D-665 for Rust Prevention Characteristics of Steam Turbine Oils in the Presence of Water.

(iv) A cooperative test program for ASTM Committee D-2 on Petroleum Products has recently resulted in the adoption of a new ASTM Standard (D 2596-67T) entitled "Extreme-pressure Properties of Lubricating Grease".

(v) Repair of Aircraft Fuel-Cells

A method has recently been developed for rapid repair of aircraft fuel-cells in situ. This method has tremendous advantages to operational units and has also attracted the attention of the USAF.

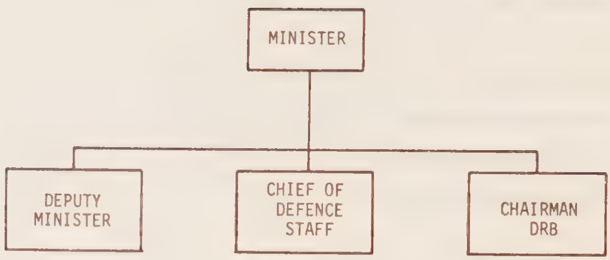

MINISTER
DEPUTY MINISTER
CHIEF OF DEFENCE STAFF
CHAIRMAN DRB

Figure 1

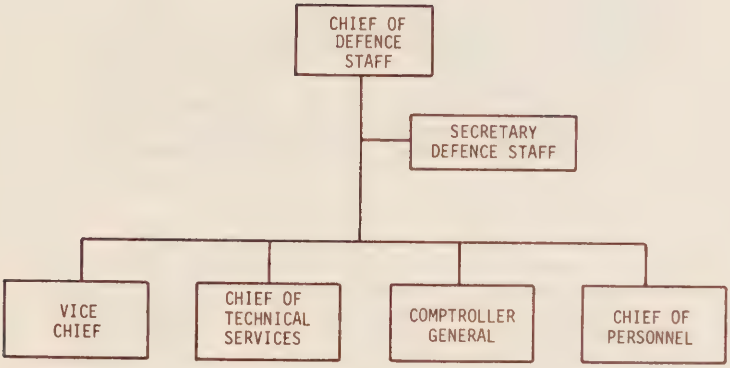
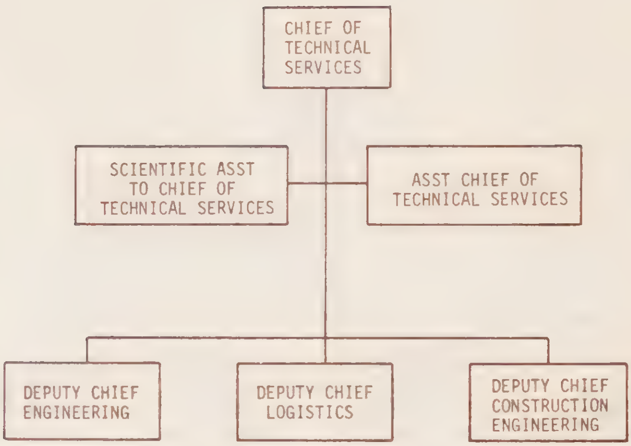

CHIEF OF
DEFENCE
STAFF
SECRETARY
DEFENCE STAFF
VICE
CHIEF
CHIEF OF
TECHNICAL
SERVICES
COMPTROLLER
GENERAL
CHIEF OF
PERSONNEL

Figure 2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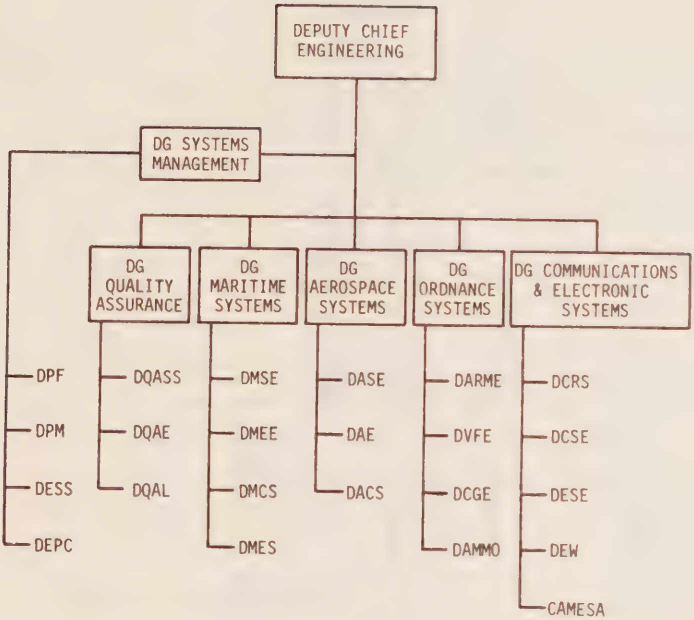
DEPUTY CHIEF ENGINEERING
DEPUTY CHIEF LOGISTICS
DEPUTY CHIEF CONSTRUCTION ENGINEERING

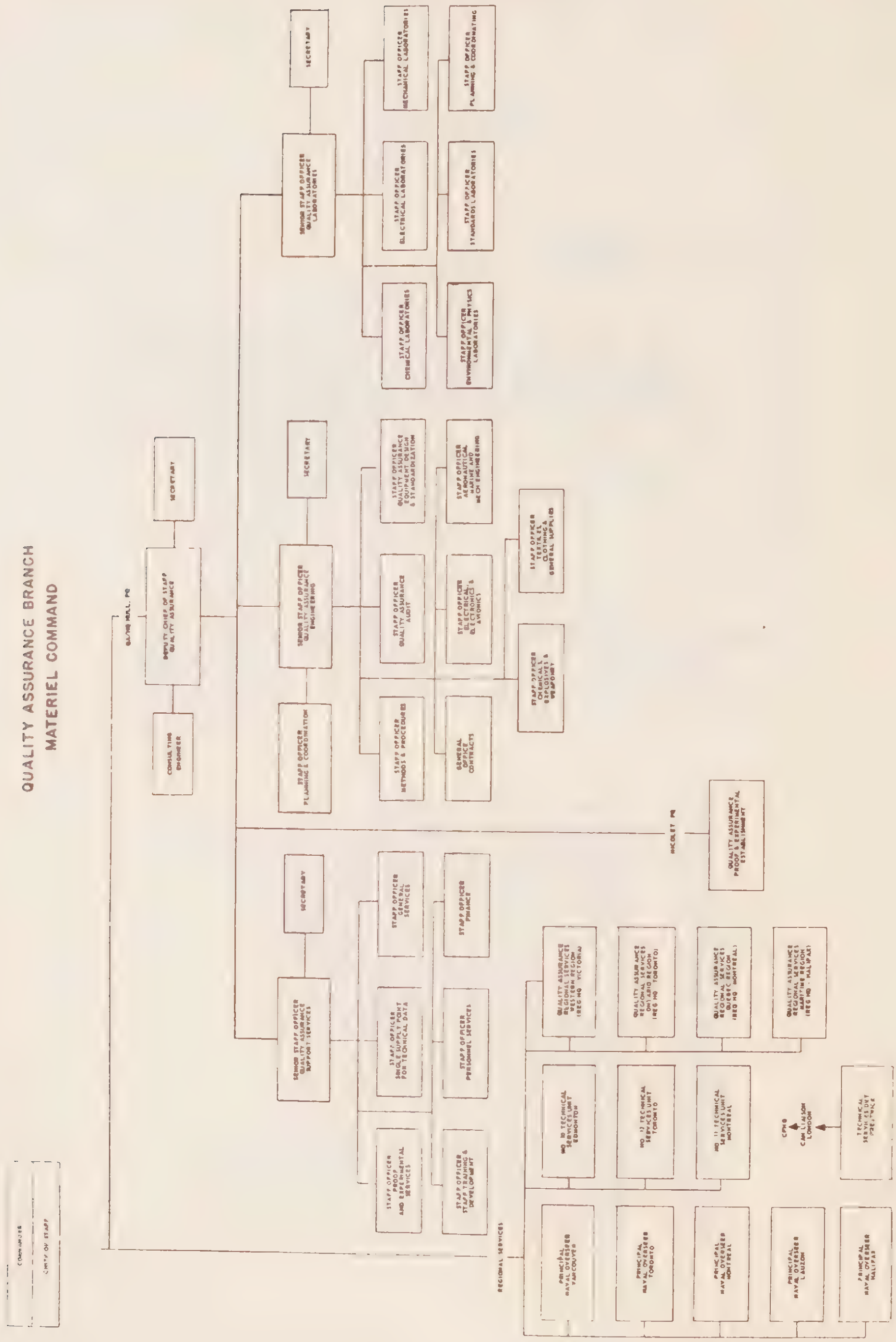
Figure 3



DPF - Director Project Formulation
DPM - Director Project Management
DESS - Director Engineering Standardization & Services
DEPC - Director Engineering Plans & Co-ordination
DQASS - Director Quality Assurance Support Services
DQAE - Director Quality Assurance Engineering
DQAL - Director Quality Assurance Laboratories
DMSE - Director Maritime Systems Engineering
DMEE - Director Maritime Equipment Engineering
DMCS - Director Maritime Combat Systems
DMES - Director Maritime Engineering Support
DASE - Director Aerospace Systems Engineering
DAE - Director Aeronautical Engineering
DACS - Director Aerospace Combat Systems
DARME - Director Armament Engineering
DVFE - Director Vehicle & Field Engineering
DCGE - Director Clothing & General Engineering
DAMMO - Director Ammunition
DCRS - Director Communications Requirements & Support
DCSE - Director Communications Systems Engineering
DESE - Director Electronics Systems Engineering
DEW - Director Electronic Warfare
CAMESA - Canadian Military Electronics Standards Agency

Figure 4

APPENDIX 1 — ANNEX X



APPENDIX 2 — ANNEX X

TERMS OF REFERENCE

QUALITY ASSURANCE BRANCH

The Quality Assurance Branch is responsible for:

(a) Developing and promulgating quality assurance procedures, instructions and standards to implement quality assurance responsibility.

(b) Storing, reproducing and distributing technical data produced by design authorities which is required:

(i) for tendering purposes,

(ii) to guide manufacture,

(iii) to govern quality assurance,

(iv) for reference purposes (not including operational data),

(v) developing and giving direction to a Single Supply Point unit to carry out these activities.

(c) Providing materiel laboratory services.

(d) Directing proofing and testing services for all types of weapons and projectiles coming into service from manufacturers and other suppliers and for reproofing of ammunition and explosives as requested by the Canadian Armed Forces.

(e) Maintaining custody of departmental standards and the calibration of lower level reference standards (Category 4, CFP 129), against them.

(f) Providing design and custodial services necessary for the provision of gauging and instrumentation equipment in support of the quality assurance function.

(g) Implementing programmes for qualification, for approval, and for the feedback of information on contractor performance for procurement use.

(h) Being responsive for design monitoring assignments in contractors' plants when so tasked, and for the exercise of the degree of authority delegated by the design authority.

(j) Providing the design authority with feedback information, comments and recommendations on design data, from the production and quality assurance standpoints.

(k) Controlling the issue of government owned materiel called for in a contract within existing procedures, and for providing information related thereto as requested.

(m) Providing specialized Quality Assurance training within Materiel Command.

(n) As directed providing assurance of quality of materiel procured, repaired or modified by contract for:

(i) Allied Governments.

(ii) Foreign Governments receiving Canadian aid (including Colombo Plan).

(iii) Canadian Government Supply Service.

(iv) Other Canadian Government Departments.

(o) Co-ordinating, supervising, and directing the activities of the Senior Staff Officers in the Quality Assurance Branch.

APPENDIX 3 — ANNEX X

CO-OPERATIVE ACTIVITIES

1. Informal inspection agreements with countries other than NATO (i.e. Sweden, Australia, etc.).

2. Inter-Departmental Paint Qualification Board.

3. Inter-Departmental Qualification Board on Waxes, Cleaners and Polishes.

4. C.G.S.B. Committees.

5. Federal Drug Procurement Board.

6. NRC Committee on Paint Research.

7. NATO Committee of Experts.

8. International Standardization Organization (ISO).

9. American Standards of Testing Materials (ASTM) Working Group.

10. Technical Co-operation Program (Quadripartite) — Chemical/Metallic Materials and Testing Methods.

11. ABC Naval Tripartite Fuels and Lubricants Committee.

12. Emergency Measures Organization — Testing medical supplies, etc.

13. Annual Test and Development Agreement with DRTE for research development testing of Alouette — ISIS and subsequent anticipated models of satellites for DRB.

14. Annual Test and Development Agreement with DRTE for research development of radio-active isotope shipping containers.

15. Annual Test and Development Agreement with AECL for research development of radio-active isotope shipping containers.

16. Annual Test Agreement with DPW to loan laboratory facilities and technical supervision for testing lumen output of incandescent lamps.

17. Qualification Approval and Specification of Contracts with DDP on electric lamps.

18. International Commission on Illumination (CIE) — international standards on photometry.

19. Quality assurance testing of textiles, clothing, equipment, fire hoses, money bags, twine, prefabricated buildings, and miscellaneous items as applicable for:

(a) Department of Transport

(b) Department of Fisheries

(c) Department of Northern Affairs

(d) Department of Agriculture

(e) Department of Justice

(f) Department of Health and Welfare

(g) Department of Lands and Forests

(h) Canada Post Office

(j) Canada Mint

(k) Canadian Commercial Corporation

(m) Emergency Measures Organization

20. Department of Transport - Flight accident investigations, Testing of textiles, clothing, seat belts and miscellaneous equipment.

First Session—Twenty-eighth Parliament
1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
STANDING COMMITTEE
ON
SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*
The Honourable DONALD CAMERON, *Vice-Chairman*

No. 5

WEDNESDAY, OCTOBER 30th, 1968
THURSDAY, OCTOBER 31st, 1968

WITNESSES:

Atomic Energy of Canada Limited: J. Lorne Gray, President; Dr. W. B. Lewis, Senior Vice-President (Science); Donald Watson, Vice-President (Administration); R. F. Errington, Vice-President (Commercial Products); and David A. Golden, a Member of the Board of Directors.

APPENDIX:

5. — Brief submitted by Atomic Energy of Canada Limited.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29101—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird
Belisle
Bourget
Cameron
Desruisseaux
Grosart
Hays
Kinnear
Lamontagne
Lang
Leonard
MacKenzie
O'Leary (*Carleton*)
Phillips (*Prince*)
Robichaud
Sullivan
Thompson
Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDER OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—

The question being put on the motion, it was—

Resolved in the affirmative."

29101—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

MORNING SITTING
(first session)

WEDNESDAY, October 30th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Cameron, Desruisseaux, Grosart, Kinnear, Lang, Leonard, MacKenzie, Robichaud and Yuzyk.—(12)

Present but not of the Committee: The Honourable Senator Giguère.—(1)

In attendance:

Philip Pocock, Director of Research (Physical Science).

The following witnesses were heard:

Atomic Energy of Canada Limited:

James L. Gray, President;
Dr. W. B. Lewis, Senior Vice-President (Science);
Donald Watson, Vice-President (Administration);
R. F. Errington, Vice-President (Commercial Products); and
David A. Golden, a Member of the Board of Directors.

(*A curriculum vitae of each witness follows these Minutes.*)

At 12.25 the Committee adjourned until 3.30 p.m. this day.

AFTERNOON SITTING
(second session)

The Committee resumed at 3.30 p.m., the Chairman, Senator Lamontagne, presiding.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Cameron, Grosart, Kinnear, Lang, Leonard, MacKenzie, Robichaud, Thompson and Yuzyk.—(11)

Present but not of the Committee: The Honourable Senators Benidickson and Giguère.—(2)

In attendance:

Philip Pocock, Director of Research (Physical Science).

The witnesses were further questioned.

At 5.40 p.m. the Committee adjourned until 10.00 a.m., Thursday, October 31st, 1968.

MORNING SITTING

(third and final session)

THURSDAY, October 31st, 1968.

Pursuant to adjournment and notice, the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Grosart, Kinnear, Lang, Leonard, MacKenzie, Robichaud and Thompson. (11)

Present but not of the Committee: The Honourable Senator Giguère. (1)

In attendance:

Philip Pocock, Director of Research (Physical Science).

The witnesses heard at the morning and afternoon sittings on Wednesday, October 30th, 1968, were further questioned.

The following is printed as an Appendix:

5. Brief submitted by Atomic Energy of Canada Limited.

At 11.45 a.m. the Committee proceeded to its next order of business.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Gray, James Lorne. Born 2 March, 1913, Brandon, Manitoba. Schooling, Winnipeg Public School, Saskatoon High School, University of Saskatchewan, B. Eng. 1935, M. Sc. (Mech. Eng.) 1938; 1938, Canadian General Electric Test Course; 1939, Joined staff of University of Saskatchewan as Lecturer in Engineering; 1939-1945, Air Force (retired as Wing Commander); 1945-1946, Associate Director-General, Research and Development Division, Department of Reconstruction and Supply, Ottawa; 1946-1948, Montreal Armature Works Limited, Montreal; 1948, Scientific Assistant to the President, National Research Council; 1949, Chief of Administration, National Research Council—Chalk River Project; 1952, General Manager, Atomic Energy of Canada Limited; 1954, Vice-President, Administration and Operations, Atomic Energy of Canada Limited; 1958, President, Atomic Energy of Canada Limited; 1961, D. Sc. University of British Columbia, LL. D. University of Saskatchewan; Member of the Association of Professional Engineers of the Province of Ontario; Member of the Engineering Institute of Canada.

Lewis, Dr. W. B. Dr. Lewis was born at Castle Carrock, Cumberland, England, June 24, 1908. He was educated at Clare House Preparatory School, Beckenham, Kent; Haileybury College, Hertford; and Cambridge University. From 1930 to 1939 he worked at the Cavendish Laboratory, first with Lord Rutherford on alpha radioactivity, then with J. D. Cockcroft on nuclear disintegrations by particles accelerated by high voltages and on the construction and operation of the Cambridge cyclotron. From 1939 to 1946 Dr. Lewis was on loan to the British Air Ministry for radar work and at the end of the war was chief superintendent of the Telecommunications Research Establishment. In 1946 he went to Chalk River as Director, Division of Atomic Energy Research, National Research Council of Canada. When Atomic Energy of Canada was formed in 1952 to take over nuclear research from NRC, Dr. Lewis became Vice-President, Research and Development. He was appointed Senior Vice-President (Science) of AECL, his present position, in 1963. Dr. Lewis holds honorary doctor of science degrees from Queen's University, the University of Saskatchewan, McMaster University and Dartmouth College, N. H. Dalhousie University and Carleton University have conferred honorary doctor of laws degrees on him. In 1966 Dr. Lewis was the first recipient of the Outstanding Achievement Award of the Public Service of Canada. In 1967 he was co-winner of the Atoms For Peace Award, in recognition of his services at the international level in promoting co-operation in the development of possibilities for beneficent uses of atomic energy, and named a Companion of the Order of Canada in December of the same year.

Watson, Donald. Mr. Watson, Vice-President, Administration, Atomic Energy of Canada Limited, was born in Bristol, England, on May 19, 1919. He obtained a BA in Physics at Oxford University in 1940 and an MA in 1945. From July 1940 to December, 1944, he was with the Telecommunications Research Establishment (TRE) in England; and from December, 1944 to February, he was Assistant to the Superintendent-in-Charge, TRE Advance Base, Bom-

bay, India. Mr. Watson went to Chalk River in March, 1946 as the Administrative Officer of the UK staff stationed there. From May, 1948 to February, 1950, he was seconded to the staff of the National Research Council as Assistant to the Research Director. In March, 1950, he transferred to the Canadian staff. In 1956, Mr. Watson moved to Ottawa on being appointed Secretary of AECL. In 1963, he was appointed Vice-President, Administration.

Errington, R. F. Mr. Errington, Vice-President, Commercial Products, Atomic Energy of Canada Limited, was born near Goderich, Ontario, and attended Goderich Collegiate Institute. He graduated from the University of Toronto in mathematics and physics in 1939, and in 1940 received a Master of Arts degree in physics from the same University. For several years Mr. Errington was active in the field of geophysical and geochemical research associated with oil and other mineral exploration in Canada and the United States. From 1942 to 1946 he was engaged in radar production work at Research Enterprises Limited where he became Manager of Quality Control. In 1946 Mr. Errington joined Eldorado Mining and Refining Limited and established a group to handle the processing and sale of radium and subsequently radioisotopes. This group designed and introduced cobalt 60 therapy machines and installed the world's first commercial unit in 1951. In 1952 this operation was transferred from Eldorado Mining and Refining Limited to Atomic Energy of Canada Limited. Mr. Errington became Manager of the newly formed Commercial Products Division of AECL. In 1963 Mr. Errington was appointed Vice-President, Commercial Products.

Golden, David A. Mr. Golden was born in Sinclair, Manitoba on February 22, 1920. He graduated from the University of Manitoba Law School with the degree of LL.B., in 1941, and received the Honourable Alexander Morris Exhibition for highest standing in all four years of the University law course. He was appointed Rhodes Scholar in 1940. Mr. Golden enlisted in May, 1941 in the 1st Battalion, The Winnipeg Grenadiers, and served in Canada, Jamaica and Hong Kong. He was a prisoner of war in Hong Kong from December 1941 until September 1945 and was discharged from the army in December, 1945, with the rank of captain and adjutant. In January, 1946 he started the practice of law in Winnipeg with Mr. Samuel (now The Honourable Mr. Justice) Freedman, under the firm name of Freedman and Golden. He attended The Queen's College, Oxford, from October, 1946 until June, 1947. On his return to Winnipeg he resumed the practice of law and also lectured at the Manitoba Law School. In May, 1951 Mr. Golden joined the Department of Defence Production as Director of the Legal Branch and a year later assumed the additional post of Associate General Counsel. In February, 1953 Mr. Golden was made Assistant Deputy Minister and General Counsel of that department. Mr. Golden was appointed Deputy Minister of Defence Production on September 30, 1954, and became President of the Northern Ontario Pipeline Crown Corporation in June, 1956. Appointment to his present position, President of Air Industries Association of Canada came on July 1, 1962. Mr. Golden also serves as a Governor of Carleton University, Vice-President of National Capital Arts Alliance, Vice-President of Ottawa Canadian Club, and a Director of Atomic Energy of Canada Limited. He is married to the former Molly Berger of Estevan, Saskatchewan, and has three children; two sons and one daughter.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

MORNING SITTING

Ottawa *(first session)*

Wednesday, October 30, 1968.

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, we are all aware of the great contribution made by Canadian scientists over the years to nuclear science and technology. That contribution began during World War II and became even more significant after the establishment of Atomic Energy of Canada Limited in 1952. We are fortunate indeed to have with us today some of those who over the years have helped to maintain and expand that contribution.

I am very pleased, on behalf of the members of the committee, to welcome this morning Dr. J. Lorne Gray, who is, as you all know, President of Atomic Energy of Canada Limited; Mr. Donald Watson, Vice-President (Administration); Mr. David A. Golden, a member of the Board of Directors; Mr. R. F. Errington, Vice-President (Commercial Products), and Dr. W. B. Lewis, Senior Vice-President, (Science). I understand that first Dr. Gray wishes to make a statement.

DR. J. LORNE GRAY, PRESIDENT, ATOMIC ENERGY OF CANADA LIMITED: Mr. Chairman, honourable senators: it is an honour and a privilege, not entirely unexpected, for us to appear before you. We have read most of the minutes of the previous proceedings and are very impressed with the way your investigation is going. One of your earlier witnesses, Dr. Mackenzie (who is really the father of atomic energy in Canada and was our first President) suggested, I think, that this committee should become a permanent body, and we would certainly fully agree with that. By keeping a continual attentive eye on science in Canada, and particularly a sympathetic eye, you will render a real service to science, to the Government and to Canada.

In the preparation of this brief, which we did in a fairly short period of time, we required a lot of people to do a lot of work. We are now convinced it was very useful work. We had to do some introspective thinking in detail over a broad field. We also think the effort we put into this may contribute to defining some of the problems, and hopefully helping to solve some of the problems, which face you in your deliberations.

We are very sorry that the full French translation is not available. The preface and the first 12 chapters are available in French, but the last three have not been completed. This is due entirely to lack of time and the availability of translation staff who can translate technical data. The last two or three chapters will be very difficult to translate; some of the words are new words and we are having difficulty getting it done. However, we hope to have it done as quickly as possible.

I might direct your attention to some of the exhibits. There are a number of our documents there, if anyone is interested. This is a very small selection of our total available number of documents. If there are any that any members of the committee would like to have, we will be happy to arrange that they receive them.

In the preparation of AECL's submission on its scientific activities, every endeavour has been made to answer the questions contained in the guideline issued by your committee. Most of the questions require lengthy answers, so the material submitted can scarcely be called "brief."

2. The information requested in the guideline is contained in appendices to this submission, which for the most part have been prepared by the AECL sections directly concerned. You will find there as well a short historical review of AECL's activities and a chapter headed Background and Prospect. These have been added to give better perspective to your examination of AECL's position in the Canadian scientific scene.

3. In this preface I have chosen to concentrate on points which I feel are of major importance to science in Canada and to AECL.

4. First, I should like to recommend most strongly that your committee visit some R and D laboratories across the country and meet with some of the staff. It is next to impossible to convey in words a proper feel for what is involved in the management and conduct of a major scientific and engineering program. It is easy enough to spend money on R and D but what needs continual and exhaustive effort by high quality staff is the management of the funds available in the most efficient and productive way. I hope you will find time to visit at least one of the four AECL sites, although we would like to have you visit all of them. I am sure you would find the experience most rewarding.

5. AECL has two main applied goals—nuclear power and the application of radioisotopes. We also covre a broad spectrum of scientific activities. We are involved in fundamental research, applied research, design, development, marketing and project management. In the field of isotope application we are also engaged in manufacturing. We look upon ourselves as an R and D organization, but clearly some of our staff are more involved in science than others. In the type of operation conducted by AECL a wide assortment of skills is necessary.

6. In a mission-oriented organization—and AECL is, to a large degree, mission-oriented—good management is vital. Over the years AECL has built up a strong team, but this requires continuous effort directed toward development of qualified replacements for intermediate and senior management positions.

7. It cannot be emphasized too strongly that the success or failure of an R and D organization depends upon people. Organizational structure, reviews, analyses and other measurements may all play a useful part but without the people with the right experience, motivation and ability the organization cannot be made to work successfully. I suggest that you give due weight during your deliberation to the availability of not only qualified but highly motivated staff, particularly those required for the management of scientific activities.

8. In the past twenty years AECL has evolved from being one centre, operated primarily for purposes of basic research, to a major R and D organization with world-wide connections. It has launched the Canadian nuclear power programme with its ramifications in industry and the electric utilities, and it markets a range of equipment utilizing radioisotopes. Its fundamental research programme has brought international recognition to Canada. "Chalk River" is a household word throughout the scientific world.

9. AECL is one of the largest R and D organizations in Canada but on the world scene it is relatively small. It is comparable in size to that of a single, large U.S. firm. The United Kingdom Atomic Energy Authority has over seven times the number of employees. To date, Canada has held its own in the front ranks of nations in the atomic energy field by concentrating its efforts through intensive selection of program items and by focussing on efficiency and excellence. However, Canada will be overtaken and passed by international competition in this field of atomic energy if the Canadian programme does not continue to receive adequate support.

10. A topic receiving increasing attention is the relative amount of research and development done in government, in universities and in industry. Sometimes the work done in government is called "in-house." As there appears to be a growing conventional wisdom that there should be greater expansion of R and D in industry and in universities, relative to that done in government, it seems desirable that someone should say something in defence of R and D in government. I am not attempting to whitewash government R and D or to blacken R and D in industry and in universities, but it is worthwhile reflecting on what appear to me to be some common over-simplifications.

11. First of all, I have some doubts as to whether the figures reported on R and D in government are correct, simply because I doubt that accounts are kept that way. Cer-

tainly we do not do so in AECL. We know what we spend on R and D contracts with industry and with the universities, since we account for them separately. The balance of AECL's R and D expenditures is usually classified in statistical reports as being "in-house." As an example, when we contracted with Canadian General Electric Company to design and build a nuclear research reactor for our Whiteshell Nuclear Research Establishment the expenditure of about $10 million was certainly in industry and assisted in the development of industrial capability, and should not have been charged, as it was, as an AECL "in-house" expenditure. Similarly, when AECL needs a complex major new instrument or research facility, this is invariably built in industry and some part of the total cost covers R and D done in industry; however, the whole cost of the machine is classified as an "in-house" R and D expenditure by AECL.

12. In reporting government expenditures for R and D, I would suggest the expression "done for" be used in place of the expression "done by" or "in-house." I doubt that as much R and D is actually done "in" government laboratories as is often alleged.

13. No one would deny that universities should have enough financial support to allow graduate students to do research for their Ph.D. theses. However, it must be getting progressively more difficult to find each year hundreds of worthwhile research projects, each to be accomplished by one man in about three years, unless they are part of a major R and D program. It seems timely to question whether most research done by graduates toward their Ph.D's should not be done under co-operative arrangements between universities and major research centres. I find it encouraging that some universities are already thinking along these lines, and it appears that this promising trend could be greatly expanded with benefit to all.

14. Again it is very clear that university faculty members must have the facilities to do personal research if they are to keep themselves up to date and thereby be in a position to give the best possible instruction and guidance to their undergraduate and graduate students. However, it is worth considering the extent of R and D that can best be done at universities. I have seen views expressed that in ten years' time universities should be receiving over one billion dollars per annum for their R and D activities. With some 40 universities across the country, this comes to some $25 million per university each year—not far short of what a major establishment such as Chalk River spends. With equipment and facilities costing millions of dollars, one cannot afford to let them lie idle; they must be used to the maximum, otherwise scientists with similar equipment in other countries will move ahead more quickly and the original work intended will no longer be original. When universities are equipped with extensive facilities, they will require full-time or near full-time supervision by senior faculty members or project "managers" along with large numbers of employees as operators, service men, workshop mechanics and other supporting staff. When this stage has been reached there will be very little difference between such a university research centre and a government research centre, except in name.

15. I do not accept in principle that the government laboratory is any better or any worse than a university or industrial laboratory—it all depends upon the quality and motivation of the staff, especially those in charge. Equally, I can see nothing wrong in a government laboratory being principally engaged in fundamental research, although this would be rare. In such a case one must assume that a decision has been made that the fundamental research is in the national interest. Why can a university run an observatory better than a government agency? In fact, I do not think it can, on university structures we find existing today. However, universities need direct access to major research facilities to support the teaching and education program. They must either directly control some of our major research facilities or have firm working arrangements with the operating agencies to ensure access, as required, to meet the needs of their education program.

16. If, for some reason, government laboratories are politically less desirable than university "institutes" there is a very simple approach that the United States has adopted. For example, the U.S. nuclear energy research and development laboratory at Argonne is run by a group of universities co-ordinated by the University of Chicago under contract with the United States Atomic Energy Commission. AECL could enter into contracts with Canadi-

an universities to run its two major research establishments. Then $40-$50 million would be transferred promptly to the heading "R and D in Universities" from that of "R and D in Government." Very little would be changed in the operation of the facilities although some universities might make better use of AECL facilities in their graduate research programs. The universities would also be freer and more effective in participating in research programs suited to their particular needs.

17. It seems to me that the extent of the work to be done by government, by universities and by industrial laboratories relates, to some extent, to the source of funds and who is responsible for the performance of the work.

18. I recognize that the Government should support R and D in universities. To date, this has been essentially a funding or granting operation, mainly to individuals to undertake projects they think are worthwhile. The criterion is good research, and what is supported is what is judged to be good research by experts in the relevant fields. I think university grants are fairly straightforward and the programme has been successful; they are a part of the advanced education process with training a main product. I feel that the growth of university research institutes is an essential part of the future research community in Canada and plans should be taking shape now to expand the existing small groups and to prepare for new groups.

19. I also recognize that the government should support R and D in industry. Basically, this is a subsidy directed toward new products or improvements to existing products for the general economic improvement of the country as a whole. Industry should decide what it wants to do and, although government support should be forthcoming for promising and well directed programmes, industry participation in programme costs is highly desirable.

20. However, in my view the majority of the R and D funds made available by government should be directed toward targets the government wishes to meet. In our form of government a minister recommends funds for his department or agency, and funds are approved by Parliament. The minister is responsible for seeing that the work needed is done promptly and efficiently and he, in turn, holds his deputy minister or the president of the agency reporting to him responsible for directing the program. These officials must be satisfied that the funds are equitably distributed and used efficiently and effectively. Support of work in industry that is not related to a government programme is difficult to justify and unless our industries take some initiative to implement programmes they feel are important to their future and to support them technically, personally and, to some extent, financially, all the government support in the world for "industrial research" will be an exercise in futility.

21. The difficulty gets far worse in times of restricted budgets. If funds are plentiful it is relatively easy to set fairly broad goals and to attain them. With a restricted budget, a very close and detailed control is necessary to reach the desired goals. It is much easier and more efficient to control work under your own direction than to co-ordinate work done by others not responsible to you. I am not proposing that this is best for the country in the long run, but it is certainly the most productive way of achieving results in the short run when budgets are tight.

22. AECL would be in a much better position to support R and D in industry in the atomic energy field if companies—particularly Canadian-controlled companies—were in a position to invest their own funds and their own efforts either independently or under some co-operative arrangement. Such work is virtually non-existent today but we are hopeful that, as the market for products in this field grows and through encouragement by AECL and others as to the general value of R and D for the future health and prosperity of Canadian companies, we will see a change, with management investing in R and D and wholeheartedly supporting a growing programme within their companies.

23. AECL spends about 20 per cent of its budget in industry on technical work related to AECL objectives. Between $6 and 7 million is spent on R and D contracts with industry and about $750,000 on contracts with universities. To get proper returns from these expenditures we have found by experience that there are significant additional expenses entailed in providing for the necessary direction and evaluation of the work. A rough yardstick is one AECL employee to five contract employees. We could usefully support more R and D in industry, provided extra

contract funds were available to support such work, coupled with the additional funds necessary for the supervision of these contracts by AECL personnel; or if industry would come forward with programmes they originate in the atomic energy field and feel are sufficiently important to justify industry and AECL joint expenditures.

24. Except for fundamental research, the economic returns that justify expenditures on R and D relate to impraved or new products or processes. These are put into effect by industry. For this reason the argument is put forward that the R and D should be done in industry so that industry is in a position to apply quickly the results of the successful programmes. In practice, however, there are a number of deterrents to full support by government of R and D in our industry—the lack of real interest by the majority of Canadian companies in investing any talents or efforts in R and D unless it is totally funded and to a large extent managed by the government and, additionally, where large organizations are involved we face the possible monopoly position of individual companies and the problems of foreign ownership.

25. In the nuclear power field AECL could have stayed out of the design and development of nuclear power stations and transferred the responsibility to a manufacturer. This procedure was in fact tried on the first nuclear power station but, for a number of reasons, the procedure was changed. The monopoly position of a designer-supplier of large power stations was not acceptable to the customer (the utilities) from a competitive price point of view; other Canadian suppliers were inhibited from getting into a competitive position for equipment supplies for prospective Canadian and foreign nuclear power stations, and normal industrial competition, to ensure maximum ingenuity in equipment supply and performance, was to be inhibited.

26. Under the system adopted (where AECL acts as the nuclear designer and directs the development of nuclear power systems) all qualified suppliers have equal opportunities to bid on components. Several hundred firms are involved in equipment supplies and services for each nuclear power station. Development funds are distributed as widely as possible and only in rare circumstances does AECL limit its support to one firm on one item, and only then when there is no reasonable alternative. Results of AECL development programmes, either from contract work or from its own special facilities, are freely available to Canadian industry to assist them in meeting the needs of the nuclear programme.

27. I have been trying to point out in the last few minutes that, particularly with limited budgets, it is important that we should see that good research and development is done in the right fields as efficiently as possible by the best people—and not get carried away by popular slogans. There are circumstances where even applied R and D is better done in government-operated facilities than in industry.

28. I suggest that it is important to place R and D in proper perspective in dealing with a social problem; we should not look upon R and D as a potential cure-all. In the matter of pollution, for example, legislation and regulations are just as important as R and D. AECL has first-hand experience in this subject, since we had to prevent pollution by radioactive wastes. This was done by determining and defining safe limits and then by rigidly following procedures, coupled with inspection, to ensure that these limits were not exceeded. We have carried out experiments on methods of waste-handling and waste-control and have improved our procedures over the years, but radioactive pollution was really controlled by regulation rather than by research.

29. Although AECL may appear to have a monopoly in nuclear reactor developments in Canada, we have internally and externally not only allowed competition but have encouraged it. We have encouraged our staff and others to propose other nuclear systems and modifications of the basic CANDU system. The use of organic liquid coolant was proposed to us by CGE and together we carried out considerable development. Many other reactor systems have been thoroughly evaluated. We have had good financial support for the nuclear programme over the years, and the vigorous stimulation of competitive ideas during the past fifteen years has kept the Canadian nuclear power programme healthy.

30. Large-scale R and D is like waging a war, and the best organizational approach has to be much the same. The generals can plan the strategy but tactics must be left to the

field commanders. They, in turn, base their tactics on information received from the front line. Clearly, the better the communications up and down the line, the better the operation. Equally, the generals cannot be successful without having superb field commanders and enthusiastic, properly trained and devoted troops. In R and D the front line troops—the working scientists—press into the unknown. What they discover produces the basis on which the research directors plan their programmes. Their job is to use their knowledge, experience and instincts, coupled with the "intelligence" from the working scientist, to decide what are the most useful things upon which to concentrate.

31. There are some fairly self-evident guiding principles. Efforts should be made to get the best possible working scientists and research directors. It is essential to keep the scientists fully informed of the desired goals and objectives but not have too rigid a control; alternative approaches to the goals should not be turned aside and at times more limited objectives reached sooner might be preferable to reaching the stated ultimate objective much later. It is also important to have an R and D centre of at least a minimum or "critical" size manned by staff with training in different disciplines, so that the staff can work efficiently, have adequate stimulation and be at close hand to help one another.

32. When looking ahead to what support the government should give R and D in the next ten years, discussions are usually centred on what major new R and D programmes should be undertaken for the social and economic benefit of Canada. Reference is also often made to expenditures in Canada as a percentage of the gross national product and comparisons are made with the percentages spent in major countries such as the United States, the United Kingdom and Japan. It seems to me that far too little attention is paid to the employment of scientific and engineering manpower. How will we employ our future professional manpower in performing worthwhile jobs in fields in which they have been trained? Are they being trained in the disciplines most needed to do the work of the highest priorities? Are we planning to train too many professionals with advanced degrees? Perhaps it is a chicken and egg analogy—if we have the work to do we must find the people, or is it that we have the people and must find the work? Without stipulated national goals and national programmes we cannot decide on the type of trained personnel needed and without an approved expenditure target we cannot decide on the number needed. These guides have not been delineated but we are well into a major programme of advanced education.

33. In 1965 Canada had about 100,000 scientists and engineers, of whom about 15,000 were engaged in R and D. In 1978 we will have some 300,000 scientists and engineers nearly three times as many as we have today. Many of these are already in the educational pipeline. With increasing numbers at our universities going on to do post-graduate work, we can expect a larger percentage of scientists and engineers to be available for R and D; perhaps as high as 20 per cent of this professional group will be capable of doing R and D in 1978—ten years from now. This means 60,000 R and D professionals. Hence, unless we can employ 45,000 new R and D professionals and perhaps 200,000 other scientists and engineers in the next ten years we will have trained a select segment of our coming generation at a very substantial cost only to find that they are either underemployed, unemployed or that they emigrate.

34. Unless plans are formulated very soon to redirect the education programme or to set up expanding organizations to employ those we educate, I am sure we will find ourselves in trouble. AECL has built up an effective team of about 1,000 professionals, some 500 of whom are engaged in research and development. We have a large base from which we can expand or diversify but as an illustration, at Whiteshell, it has taken us about seven years to establish a critical size working organization. In the next ten years it seems that if there is to be useful employment for those being educated in science and engineering Canada will need the equivalent of something like 100 new organizations the present size of AECL. The annual cost at that time would be in the region of $3 billion. To meet such a requirement—if it is a requirement—seems next to impossible.

35. Good R and D centres cannot be fashioned overnight. A proper environment can only be created by building slowly and carefully unless resources are used inefficiently. An R and D man, however good, needs the right environment and support if he is to

perform effectively. Experienced research directors and management are already in short supply.

36. If it is agreed that we do face a crisis in this field and if it is decided that we should make an effort to find suitable employment for a large increase of professionals qualified to carry out scientific investigations, I suggest that very strong support should be given to cells of excellence and that they should be allowed to expand and break up into segments to become separate and grow independently as quickly as possible. This would follow the pattern of AECL's evolution—beginning its life as a division of NRC and then being weaned and growing to maturity fairly quickly. Trying to create a new organization without a strong small cell is far more difficult. These cells need not stay under the same umbrella as their parent; they can be attached to universities to grow into institutes, they can augment industrial or provincial research organizations, or they can be "remote" units of government R and D organizations.

Thank you, Mr. Chairman.

The Chairman: Thank you, Dr. Gray. We might proceed now to the question and discussion period. Senator Aird?

Senator Aird: Mr. Chairman, Dr. Gray, distinguished colleagues at the head of the table, I was most interested in your remarks at the outset, sir, about the service that this Senate committee may have done, if only because it has required the discipline in your own agency

I am not sure, sir, of my own qualifications to speak or to question you on such a technical subject as this. As I indicated to you before the meeting, my own experience is that of a lawyer, but I did have some very strong field experience staking radium claims both at Radium City and Blind River in the earlier days, and I was your guest at Chalk River when it was first beginning.

The method that I would like to choose, if I might, is to delay some questions that I have prepared on your brief specifically, but perhaps ask you one or two general questions relating to the whole problem.

As you have indicated that you have studied the minutes of the previous meetings that we have had, you will appreciate that we are interested in goals and in priorities and in management. I think it is a great compliment to your organization, sir, that you have presented us with such a full brief. We are very grateful to you for it because we have a great deal to learn, I believe, from AECL and how it, as a mission-oriented agency, if you will, has applied science and technology.

My first question, and it is a double-barrelled one, if you like, deals with goals, and I would also like you to talk about marketing. In your capacity as President of AECL, I would like to ask you what do you regard as your greatest single problem in achieving these goals. Now leaving this with you to think about a little, the reason for asking this question relates to the marketing aspects. Are you satisfied about your marketing techniques? Are you satisfied that there is a sufficient marketing approach throughout your operation? Relaying that through to the final results, and coming back to my original question, are you on target in reaching your goals or are you off target and what is the scene?

Dr. Gray: Senator Aird, those are a couple of good questions. In the nuclear power field we have goals, and we have one in the nuclear science field which is Dr. Lewis' field and another in the Commercial Products field which is Mr. Errington's field. I will just deal with the nuclear power side where our goal is to produce a reactor system that is economically viable and competitive with any other reactor system, particularly in Canada. Our main objective is to produce low cost energy for our Canadian utilities or to get them into a position where they can produce low cost energy themselves. Parallel to that, there is an export market available to us if we can offer an economic plant that suits the export conditions. We think we have reached the first goal. We have produced in Canada—not necessarily AECL but Canadian industries and utilities, and particularly Ontario Hydro—have produced a nuclear power system which is competitive with any other system. In fact, it is a little more than competitive. But decisions on this are not made by us; that decision was made in the first instance by Ontario Hydro. They have no obligation whatever to build a Canadian type plant, and they are not noted for using only Canadian equipment and materials. However, we feel we have achieved the first goal because we have produced a nuclear power system that is economically competitive in Canada.

The Chairman: Would they have gone for this even if the Canadian Government had not financially participated?

Dr. Gray: No. The Canadian Government had to participate in the whole development initially. However, there is no participation now in power stations. Ontario Hydro is now building its power stations at Pickering with no participation on the part of the Government other than the back-up R. and D., the program we have at Chalk River and Whiteshell.

None of these power stations has yet proven itself; there is no nuclear power station in the world that has yet proven itself. There are several running. We have some running in Canada and they have some running in the United Kingdom. In fact there they have more running than any place else. They also have some running in the United States. In the United Kingdom they have the gas cooled reactor, and we have the Canadian reactors, but none of them is fully proven and they will not be proven for 25 years. However, we are all confident that they will operate for 25 or 30 years. But this is too new a business to have final proof that we have reached our goal.

There are many problems and we require a continuing effort, even on the present system, to make sure we do end up with a proven system. Even though Ontario Hydro is investing several hundred millions of dollars in the Pickering plant, we are doing work on materials related to those plants. So far as the marketing side is concerned, I don't know whether I have given you all the information you want on that, but I am sure you will come back to that.

Senator Aird: I will come back to that.

Dr. Gray: On the marketing technique side, so far as isotopes are concerned, we have this well in hand. Mr. Errington has been in this for 10 or 15 years and we have international marketing going on all the time. However, so far as nuclear power station marketing is concerned, we are just starting. In June of this year we were assigned the responsibility to do all the marketing for Canada and for Canadian industries in this field. We have been very active, but our staff is small; we only have two people who are permanently in this field, that is myself and our General Manager (Marketing), but we have a large organization generally. We have a half-dozen of the CGE group which we took over in Peterborough putting information together, and we have people in Toronto doing likewise. However, this is not sufficient, and we are trying to recruit two types of people; the first type consists of people experienced in thermal power. They don't have to be nuclear experts but they have to know about the generator end of the plant. We are very close to appointing a couple of people—they are not yet appointed—and we need a couple more on the nuclear side. Within two months we will have our team in pretty good shape.

We are at the present time in the midst of bidding on a plant in Romania. We have already quoted technical specifications and we were supposed to have the financial bid in tomorrow. We will be a week or so late. This is on a 300 megawatt reactor, and by December a 600 megawatt reactor. This a firm price bid in which we on behalf of industry will be carrying the responsibility for getting the plant put together and operating with appropriate warranties.

Senator Aird: Who are you competing with?

Dr. Gray: The United Kingdom—the UK Atomic Energy Authority—and a consortium that originally consisted of Germany, Switzerland and France, but has changed recently and consists now of France and Switzerland because Germany has become unpopular in some of the eastern countries. I think we have a very good chance of getting this. However, we have yet to go through the motions of getting approval of financing, because it will require export credits, but I would think we have a very good chance of getting this.

There are many other areas of interest we are working on. Here all I can say is that we have got a very good start. We are not big enough yet, and I think we could do with some really experienced commercial salesmen, and we are looking for them.

Senator Aird: Perhaps I might re-ask my question: Do you consider marketing to be your No. 1 priority?

Dr. Gray: No, the No. 1 priority is to ensure the nuclear power system we have developed and which is being applied in Canada in a very large way—Ontario Hydro have announced that later this year they expect to start a new plant with 3,000 mega-

watts—is an economically viable, good, solid technical type.

The Chairman: This is marketing.

Dr. Gray: If it is marketing, then it is our No. 1 target; but Canada is our No. 1 target.

The Chairman: How do you account for our failure to export up to now? Is it because we are too new, or because the Government agency responsible for marketing did not do a proper job?

Dr. Gray: No, I think we can answer that one fairly well. It is only in the last three or four years we have been in a position to offer a plant in the commercial market, and this was done by Canadian General Electric. We stayed out of it by agreement, and Canadian General Electric were set up with a fully qualified team of designers. They made two bids, one in Finland and one in the Argentine. In Finland they were as good as anyone else, but the Finns, through a series of evolutions, cancelled and no one got the work. It was arranged that they would get their power from Russia.

We understand the proposal they put into the Argentine was as good a proposal as the German bidders put in, but trade relations between the Argentine and Germany are much better than they are between the Argentine and Canada. The decision was not made on the price of the plant. The Argentine bought a heavy water natural uranium plant which is similar to the Canadian plant—the pressure system is different. It appears that went mainly on trade relations. The Government agency had nothing to do with the first two attempts. We are now starting.

Senator Aird: This was my third specific question: What is the current export position?—and you have reviewed that briefly for us. But over and above the specific question, is it necessary to have a healthy export market?

Dr. Gray: No, it is not essential to have a healthy export market and still have a healthy Canadian program, but it helps our industry. These stations they are building in Canada are very large—750 megawatts. They only do one about every year and a half to two years. This puts a very light load on our industry, and they only get an order for a piece of equipment every 18 months. If we could get a similar reactor designed for export and get twice as much equipment ordered, we feel this would allow them to produce better equipment at lower cost, so we think that the role of industrial plant is important. If you get orders in the export market it puts more industrial production into the Canadian economy. And a lot of the work is quite advanced. They are using new techniques for welding, and new materials, and are working to new tolerances, and some pieces of equipment are very difficult to build; it is good for the future of the industry. We are going into the technological age where this sort of experience will be of immense value.

Senator Aird: Coming back to the Canadian scene, another specific question: What power plant orders are now on the books, beyond the current Ontario stations?

Dr. Gray: None.

Senator Aird: Another specific question...

The Chairman: Could you comment on future possibilities?

Dr. Gray: Yes, but that is a different question.

Senator Aird: I will be pleased to ask that too!

Dr. Gray: The prospects are very encouraging, and if we do not get any of this business it will certainly indicate there is something wrong with AECL. We are putting our reputation on the line. It will be about seven or eight years before this is known, and that is when I retire!

The Chairman: You might be called to the Senate!

Dr. Gray: Yes. One of the directors, who is a member of the Executive Committee, mentioned to the chairman that I might be retired early.

We have been asked just in the last three weeks to bid on a plant in Italy. The present round of reactors in Italy is just being decided, and we could not get into that round. Canadian General Electric could have, but decided not to. We have been asked to bid on one of 600 to 750 megawatts, and a decision will be reached some time next year. I think we would have a very good chance of obtaining that work.

There is the possibility of a 600-megawatt plant in the United States, if we go after it. It is a special requirement, and it may be some time developing, and we are moving slowly on it. It is one we would very much like to get, but it will be slow in developing.

We have very active negotiations right now with China on a research reactor. It looks like it will go ahead.

With regard to Romania, we are bidding on two right now.

The Czechs are interested in a 600-megawatt reactor, and we will be putting in a proposal in November to Czechoslovakia.

South Africa have just finished completing a major review, and in their conclusion they mention they want to build a heavy water natural uranium plant of 500 megawatts, starting in late 1970, and they will be calling for world bids.

New Zealand is calling for four reactors, to come in a year apart, starting in 1971. They have specified all natural uranium heavy water reactors, and we will be bidding on that.

In Australia we expect to be invited to put in a proposal—whether a competitive bid or not we are not sure—next year for a 500-megawatt plant. My opposite number, Sir Philip Baxter, is now in Canada going through our plants.

In Brazil it looks like they are really going to go ahead and invite bids on a 500-megawatt plant. We are not clear as to whether they are going to specify a heavy water natural uranium reactor plant, but they would allow that to be bid in comptitition with others. All this comes within two or three years. There are many prospects. These are all for export.

In Canada this becomes a very big business by 1980, in Canadian installations. Ontario Hydro, in the next two or three years, are going to go for two of these 3,000-megawatt plants, each with four 750-megawatt reactors and they have specified they will continue with the Pickering type reactor—an improved version, but the same in principle. We have Hydro Quebec by about 1980—and this comes from Hydro Quebec reports.

Senator Aird: Is the Hydro Quebec contract a firm contract for Gentilly?

Dr. Gray: Yes, it is very firm. There is a picture of it, in the small exhibit and the building is up. This is a prototype plant. This is a new type of plant that no one would be prepared to build and guarantee its operation until it is operated, because it has a different type of coolant. So the Government agreed to build this plant under the same terms as the Douglas Point plant, and we are building it in co-operation with Hydro Quebec. Hydro Quebec is providing a fair amount of in-put such as training staff. They offered the site, and they are doing some of the engineering at their own cost. They will operate the plant. When it is operating successfully they will then buy the plant from the Government of Canada at a price that makes the plant competitive with a coal-fired plant, so there will be the difference between what the plant costs, us and the price offered, which will be some millions of dollars. We will not really know the difference until it is completed and we can see how it runs, but the cost will be $105 million, and it might be worth $80 million. The figures are something of that order.

But, it is a firm contract, including responsibility for completion and operation, and the pay-out clause. These matters are all firmly set out in the contract, and it is virtually identical with the contract between the Government and Ontario Hydro for Douglas Point.

Senator Aird: Would you continue, then, with the prospects on the Canadian scene?

Dr. Gray: Well, the prospects on the Canadian scene for power are primarily in the Province of Ontario. Their forecasts of installations rise very rapidly until by about 1980 when all new plants will be nuclear. This is what Mr. Robarts said the other day at the opening of a power station on the Madawaska River—I have forgotten the name of it. In Ontario it is a very important part of energy resource, and it really puts a ceiling on the cost of power in Ontario. By the time we get to 1990, the installation—well, I have not got it in megawatts; it is in billions of kilowatt hours, and it is in one of these books. There are these curves that have been developed by our people in co-operation with Ontario. The same thing happens in Quebec, but it does not start until 1980.

The Chairman: I saw a forecast that was made the other day by Quebec Hydro which said that by the year 2000 they would derive about 60 per cent of their electrical power from nuclear energy.

Dr. Gray: Yes, these are the figures we have heard, and all new installation by 1985 or so, when hydraulic power is finished, will be nuclear in Quebec.

The other one is the Maritimes. If the Maritimes get their systems interconnected—that is, if New Brunswick, Nova Scotia, and Prince Edward Island can interconnect their electric systems—then by about 1977 or so we think they can start putting in big nuclear plants, and on straight economics this is the best thing that the Maritimes can do. But, they need to have interconnection first, because their systems are too small on their own to justify a large nuclear plant. If they do interconnect we can see very definite cost advantages over other sources of power in the Maritimes.

The only other place where we would see nuclear power coming in quickly is Vancouver Island. There is a possibility there of augmenting the requirements by putting some power at the end of a DC underwater transmission line.

This kind of development will take some time in the Prairies, unless there is a requirement for a very large station, and this has been talked about in connection with a diffusion plant for enrichment. If you want, say, 2,000 megawatts at one site, then it is quite possible, if you want to locate it on the Prairies, that it might be an economic operation. If the unit was one of 2,000 megawatts you would need a very large load to go with it.

As we see it, that is the Canadian scene, and the application of atomic power on the Canadian scene.

Senator Aird: I gather that you see worldwide prospects and good Canadian prospects for the sale of the CANDU system. I do not want to overwork the marketing side, but my last question relates to a statement of yours contained on page 4 of Appendix 5. It is a very short statement, so I do not think you need to refer to it. It is:

> The Nuclear Power Marketing group is in the process of formation and is expected to reach its planned strength of about four or five professional staff in the course of one year.

You have answered my question partially in respect of this, but I should like you to tell us how you are getting along with this.

Dr. Gray: To augment that, now that we are into this, I should say that this was written two or three months ago, and I think that within the next two motnhs we should get up to that strength.

Senator Aird: Professor Christopher Freeman, who was recently in Ottawa as the guest of the Economic Council, stresses the importance of marketing and marketing research, and says:

> Too often decision-making is confined to the research and development aspect, and somebody else if left to consider the innovation aspect, above all the marketing aspect. In my view this is an almost certain recipe for failure...I would maintain that on any, certainly on any industrial, research and development project, it is usually necessary from the very outset to include people who are responsible for marketing the ultimate product.

He goes on to cite a case in point, the poor sales record for British nuclear reactors, and says:

> The R and D was conducted, I think on the whole pretty efficiently by the Atomic Energy Authority and led to very important new types of reactor, technically very well advanced....The biggest difference that I see between the American nuclear power programme, which has apparently been more profitable, and the British lies in this: that Westinghouse and General Electric were far better able to integrate the research, development, production and marketing aspects into one whole innovation process, and the chain was not broken through structural weaknesses.

You have answered my question partially by saying how AECL has been handling this aspect. I do not wish to take the absolute Freeman position, but it seems to me there may very well be an analogy between the way that AECL has developed and the way that the Atomic Energy Authority in Britain has developed. Naturally neither AECL nor any of us wish to have Canada fall into the same trap or the same situation, as the British did. Would you care to amplify on this point?

Dr. Gray: Well, Senator Aird, certainly Professor Freeman is quite right in most of what he says there, but I do not think that the reason why the United States has been

successful and the United Kingdom has been less successful is entirely because of marketing. I think it has something to do with the aspects of the systems, and the kind of product you have to sell.

In our case, our scientists, technicians, and engineers have had to convince themselves and others all the way through that we have a product that can be used in Canada, and hopefully elsewhere, that is economic.

We have not really done the sort of marketing Professor Freeman is talking about within AECL until just now. We have done it with Ontario Hydro during the last ten years on a more or less continuous basis for their own system. Ontario Hydro get offers from Westinghouse and GE in the States for these plants, so they are continually reviewing this. But, the market has been a sort of competitive market. If we were good enough then Ontario Hydro would use us, and this is what has happened.

We are now going into this other aspect, and I think you are absolutely right. The further we get into it the more we realize that this marketing requirement is very important. But, so far as AECL is concerned, we are enjoying completely the full support of the people in the Department of Trade and Commerce in, for instance, all of these areas—in Eastern Europe, in India, and in Italy. These people are extremely valuable to us. I think that we probably underestimated the requirements for marketing people when we took this on, but we are as rapidly as possible assigning people to that specific role. We have a large source of marketing expertise behind us in the CGE group. AFCL have taken the responsibility and it has to be taken out of my office when we finally go on the line for $100 million or so. We really must have more expertise and more experience in this line of work located in Ottawa, and this is what we are trying to get. I think we shall be all right; I do not think we will have the same problem the U.K. had in marketing.

We are not the same as GE or Westinghouse because all we can put into our marketing proposals are what we get from our industry. When we put forward a proposal for Romania, there is not five cents of AECL manufactured equipment; we do not produce any manufactured equipment. We have to get this bid from a hundred different companies, or estimates of what we think their bid will be. We cannot always get firm prices ahead of time. This is where our experience over the years of working with Hydro and CGE's own experience will be brought to bear, and hopefully will be right. The marketing is something we are just getting into. I am glad you have brought it up, because it makes us think even a little harder.

The Chairman: What has been the success of the United States in export marketing up to now?

Dr. Gray: The United States have exported a few plants. What they have mainly done in Germany and elsewhere is make an arrangement with AEG or Siemens, or somebody else, for licensing and then jointly bid on plants in Italy, Germany, France, Japan. They must have ten plants around the world under consideration. Is that right?

Dr. Lewis: Yes.

The Chairman: Always on a bid basis?

Dr. Gray: Not entirely. I think in Japan it is a full GE and full Westinghouse bid. In Italy it is a GE bid.

Dr. Lewis: The first two plants in Italy were what they call turnkey projects, one from GE and one from Westinghouse.

Dr. Gray: They also make arrangements with Ansaldo and Fiat, or somebody else, and go in with partnership licensing arrangements.

The Chairman: Is there any element of subsidy when they come in?

Dr. Gray: It is hard to say. We hear lots of rumours. There is no sense in the pricing of these plants. At one time the price is so much, and the next time you hear it the price is up 25 per cent or down 25 per cent. There is no doubt that some of the American plants have been loss leaders in and around the world. The price of American plants is rising rather rapidly, for what reason we do not know. There is no doubt that GE and Westinghouse have a tremendous stake in this, with tens or hundreds of millions of dollars invested at this stage, and they expect to get it back. But I do not think there is much direct government subsidy in the American program. The United States AEC spends ten times as much of its budget in its R and D support of civilian nuclear power but I do not know of any direct subsidy in connection with GE and Westinghouse.

The Chairman: Normally would this larger scale operation tend to reduce cost?

Dr. Gray: You would expect costs to be coming down, but as they build more plants they are getting more experience of what the costs actually are in relation to their bid price.

The Chairman: We have not reached that stage yet. I think we should adjourn for a short time at this moment. If the members of the committee would agree, I think this is a very important aspect—marketing—so we might go round the table after the adjournment on the marketing problem, because it seems to be basic to our whole hearing.

Senator Grosart: May I ask a supplementary question?

The Chairman: Yes.

Senator Grosart: Was your decision to assume this total marketing responsibility made before or after the CGE pull out?

Dr. Gray: After. They came to us and asked if we would take this group over, and after that the Government approved our recommendation that somebody should represent Canada. We had stayed right out of the nuclear power marketing business while CGE were operating.

Senator Grosart: You say you have informed industry you do not intend to stay in permanently, the nuclear power business.

Dr. Gray: Nuclear power sales. As soon as CGE, Canadian Westinghouse, B. & W. wish to start selling nuclear power stations we should be delighted to get out of it.

Senator Grosart: Would it be fair to say that your marketing decision was involuntary?

Dr. Gray: Not quite. I think we wanted to see somebody take this on, otherwise Canada was not going to be in the export business.

The Chairman: It was more or less forced on you?

Dr. Gray: Yes.

The Chairman: Since the company wanted to get out.

Dr. Gray: Yes.

(*Short recess*)

(*Upon resuming*)

The Chairman: Are there any more questions on marketing?

Senator Desruisseaux: Speaking about marketing, there was mention of 600 and 750 megawatt plants. It may be well for us to know what it implies to make a 600 and pass to a 750 megawatt plant. It is a small matter to read it, but it may mean a lot more.

Dr. Gray: Ontario Hydro is building 500 megawatt plants now, four of them. They are well on. The first one you can see in the photographs there in the exhibit. The first two will be operating in 1971. To go to 600 megawatts was fairly simple. It just required operating the fuel and the pressure channel at a little higher rating than we had proved to be feasible in the reactors at Chalk River and at NPD with a small reactor.

It took very little design change to go from 500 to 600. We do not have a 600 in Canada but we are bidding on 600 megawatts overseas, and it is simply an uprated 500. It is the same type—it produces the same steam, but we may allow a little boiling in the channel, to get a little extra energy out. That is fairly simple. Going up to 750 megawatts is a little more of a problem. It is fairly simple, in that you probably put in more tubes. If one reactor has 300 tubes, and you are going up to 750, you may put in 700 tubes. You put more fuel in. Of course, it is not quite that simple, in the 750 megawatt reactors. I have not kept up to date on it but I think we are using a different control principle. With the heavy water moderator, we normally dump the moderator to control the reactor. But I don't think that in the 750's we do so.

Dr. Lewis: In the 500 megawatt, we are not controlling it in this way. We are able to dump as a protective measure. The protective measures become less potent as you go to higher power. We are relying more on protective shut-off rods.

Dr. Gray: Increase in power is done mainly by more of the same tubes. The NPD reactor was the first one with 20 megawatts. Then we went to a 200 megawatt reactor. Then there was the 500 megawatt reactor at Pickering—they were all the same except for the number of tubes. I think that the rating—the amount of energy you can get out of one of these fuel bundles—is going up. But the fuel bundles are very similar. We find you can operate at higher temperatures, higher pressures, and still be safe.

Dr. Laurence is here from the Atomic Energy Control Board. We are required to meet their regulations and their safety limits, the temperatures, as to what atomic rating to take the fuel to. We have done experiments on this, and these are the valid safe limits.

We are going up slowly in these limits. The change is partly in putting more tubes in and partly increasing the rating of the core of the reactor.

Senator Desruisseaux: As to the plans for the future, is it towards larger plants?

Dr. Gray: In this line of reactors, we would expect Ontario Hydro to go to 1,000 megawatts—after two big stations at 750—then probably 1,000, for this line of reactors.

We have a major program under way at Chalk River, to try to do two things. One is to lower the capital cost of these plants, which is high—if we can see a way of doing this with the intensive development program. The other thing is to increase efficiency. The efficiency overall is about 29 or 30 per cent. We would like to go to 40 per cent. If we can get that, we can afford to spend some millions of dollars doing it, and get a good result, a good payoff. We would also like to go to higher temperatures, perhaps to a superheat in the reactor. But we are in no position to offer this commercially and we will not be for five or ten years. However, we can see real advantage ahead of us on this type of plant—to spend more money, to increase efficiency, and lower capital cost. If we accomplish that, we have then to get into a different system. Dr. Lewis has some systems up his sleeve, for using energy from thorium, and this is further along the line.

The Chairman: We might come back later on to technology.

Senator Lang: I wonder if Mr. Gray might comment as to whether the recent political developments in Europe, particularly in Czechoslovakia, will have an effect on us, in regard to plants in Czechoslovakia and Romania. I would also ask whether perhaps Canada's position, its military posture, in Europe is having an effect on these problems.

Dr. Gray: It seems to be having no effect, at least in Romania. So far as we can see, our discussions with Romania are going very smoothly. In regard to Czechoslovakia, at first we were not aware that they were interested in our plant. I went over in June, as we were going to Romania, in regard to the power project, and to Russia for a visit. In the case of Romania, it was a sales visit, but we decided to do a sort of formal visit to Czechoslovakia and Russia.

When we got to Czechoslovakia we found that they were not so interested in the formal visit; they wanted to talk about the supply of a nuclear power station, and they wanted us to visit plants that they have and asked us to bid on a plant.

We went to Russia and told the Russians that the Czechs were asking us to bid, and the Russians said that if this was actually to be a heavy water power reactor, they wished "more power to us" and they would not object.

We raised the question of Finland. Obviously Russia had stopped Finland from going into nuclear power and we were told we should proceed, there would be no objection.

Then August 6th came along and we did not hear anything from the Czechs. I had actually written, but I did not hear anything. I was in Vienna in September for the International Atomic Energy Agency General Conference and the Czechs very specifically sought me out. We had a meeting with my opposite number, the chairman of the Czech Atomic Energy Committee, and his senior people. They reasserted their interest in a Canadian plant and they assured us that this had been cleared in discussion with the Russians, and would we please expedite our bid—which we have done.

I also spoke to the Russian atomic energy man and told him what we were doing; and again he reiterated that if we were offering a heavy water natural uranium plant, he thought we had the best system of that type in the world and we should go ahead.

Three months from now, we will be able to give you the real story.

Senator Yuzyk: It is gratifying to read about the success of cobalt-60. I understand that we have quite a lucrative export trade in cobalt-60. Are we still ahead in this field in the world?

Dr. Gray: Certainly commercially we are ahead. We are more involved in the sale of not only cobalt 60 but the equipment to use it, both for medical treatment and for radiation treatment and work in the research and development field. I do not think there is any

question but that our equipment is the best in the world—it is under Mr. Errington's guidance. It has been adopted all over the world by many people. I do not know if I can say more now, other than the fact that we supply more equipment to more hospitals around the world than anyone else, and more cobalt of this type than anyone. We are staying ahead in the case of equipment design. I think that the use of cobalt is pretty well known, so the use of it for medical treatment has probably pretty well settled down, the use as a radiation source has pretty well settled down. As to the use of it in other sources—we have a potato irradiator down near Montreal, where we built a plant to irradiate potatoes. That is coming. I do not have any doubt that we are further advanced than anyone else, except perhaps the United States Army—and perhaps even there.

Mr. R. F. ERRINGTON, VICE-PRESIDENT (COMMERCIAL PRODUCTS) ATOMIC ENERGY OF CANADA LIMITED): I might suggest a few things, starting at the end and working towards the beginning.

I think we are in a very good position in terms of major design and supply of major radiation, that is, gamma radiation facilities. We have done a good deal of work on food irradiation. Food irradiation has not really become a big thing yet in terms of supply, although its potential in the future is very big. It has had its problems. In terms of other major irradiation facilities, I think we are in a very strong position. The types of major irradiation facilities that are now coming in fairly rapidly are those used to sterilize hospital disposables such as surgical sutures and hypodermic syringes.

There have been quite a number of such plants builts in the world within the last four years, and I think that we have had our fair share. We built all of the early ones in North America, mostly in the United States; that is, all the early ones which were paid for by private money, where a competitive bid was very important. We did not get all the U.S. government irradiation facility orders. In fact, we got very few. We have been able in this type of field to break into the European market, against very heavy competition from Germany, France, Britain and Switzerland. We have been able in the last four months to commission two major plants in Europe as well as one in New Zealand. I think with respect to the matter of designing and producing major irradiation facilities that we are well ahead or well up with anyone else. We have certainly supplied more than any other individual group.

Senator Yuzyk: Do we still have a good share of the American market for cobalt 60?

Mr. Errington: For that type of thing, I think we have a good share; a much better share in terms of the cobalt therapy machines used for cancer treatment. We have almost an embarrassing share of the United States market for such machines. Yes, I think we have a good share.

The Chairman: Why is it embarrassing?

Mr. Errington: Because when it becomes too big sometimes the rules are changed.

Senator Lang: That is a good answer.

Mr. Errington: We also have in that field a very good market in Europe—France and Italy. We also have a developing market, in spite of local hardware manufacturing by four companies, for hardware in Japan, which is very surprising to us.

Senator Cameron: What about the patent situation on this equipment? Who holds the patents?

Mr. Errington: We hold many of them, most of which are being violated by most of our 30 or 40-odd competitors. We have never taken any action against them because this, after all, is in the interests of humanity and we think we should be able to hold our position regardless. I am not sure whether it would be in the best interests of anybody to take action on this.

Senator Cameron: Then there is not much revenue coming from that source?

Mr. Errington: No.

Dr. Gray: There is no revenue, it is rather like a gentlemen's agreement. The use of these is pretty broad. Just for the record, we have sold, by August of this year, 653 cobalt beam therapy machines in 52 countries; and with respect to commercial irradiation facilities, 219 in 35 countries. This work that is done by our Commercial Products group, where we have had marketing experience for the last 20 years, results in about $10 million a year in sales, 90 per cent of which are exported.

Senator Grosart: Mr. Chairman, I believe Canadians are naturally concerned with the

possibility of parent foreign countries inhibiting the competition in international markets by Canadian subsidiaries. I am wondering if the Canadian General Electric situation is a case in point, because quite interestingly, and I presume coincidentally, on page 6 of Appendix 6 we have first of all in paragraph 16 a statement that CGE informed AECL that they were not prepared to carry on. They suggested that a merger with AECL would be in the best interests of CGE, AECL and Canada.

I would like to see those three names in the reverse order.

Dr. Gray: I'll have to see my editing staff about that.

Senator Grosart: I will not bother to relate that to a rather famous quote of Mr. Wilson of General Motors. Then in the next paragraph, speaking of competition in the world market, the following words appear:

> It must be remembered that the competition abroad is from huge organizations such as General Electric and Westinghouse in the United States, the United Kingdom Atomic Energy Authority in Britain and Siemens in Germany.

This seems to me to be a case where the Canadian subsidiary has pulled out so far as competition is concerned, leaving the field especially to the parent organizations of these two industrial entities.

I wonder if you could give us a little more information on this statement or suggestion by CGE that they were not prepared to carry on. Did you ask them why? Did you protest this? Did you ask them, "Is it money? Can you not get the money from your parent company?" Or do you see in this situation the kind of danger that we seem to be eternally faced with in Canada in respect of parent and subsidiary companies?

Dr. Gray: Well, senator, I do not see any danger in this particular one. We have been pretty close to this for 10 years. I think Canadian General Electric have been allowed to proceed in this field as though they were not a wholly owned subsidiary of General Electric Corporation. Certainly they have had a free hand in Canada so far as I am aware and in the world market as well. I do not know that they had a free hand in the United States; they probably could not have sold in the United States.

We did probe why CGE wished to pull out of this; in fact, we were very much interested. The main reason is that CGE, as a nuclear power station supplier, did not have access to the Canadian market. The reason they did not have access to the Canadian market, and I am being quite straightforward, is that Ontario Hydro is the Canadian market at the moment and Ontario Hydro is not prepared and has never been prepared to tie itself to one supplier. The whole history of Ontario Hydro, and of most of our utilities, is to call for competitive bids. They like to get at least three competitors to bid on any equipment. So very early in the game, 10 or more years ago, they made it quite clear that they would be buying on the open market. The only way they could do this was to design the plants themselves or have them designed for them by a consulting engineer. They would not buy a complete plant from Canadian General Electric, where there was no competition. We have actually been the consulting engineers for Ontario Hydro in the nuclear end. They are their own consulting engineers so far as the rest of the plant is concerned.

Canadian General Electric has an equal chance to bid on pieces of equipment but not on the whole plant. So with no access to the Canadian market, and trying unsuccessfully for a market in Finland and the Argentine, they had invested all the money in this field that they felt they could as a Canadian company.

Whether they should have been instructed by the American company or by anybody else to invest more money and to try to keep it going is a moot point. But they decided—and whether it was a totally Canadian decision or not, I am not aware—they decided that they could not invest any more money in trying to get foreign business, and I think also that they concluded that for at least the next few years there would not be enough business to keep the group healthy in the foreign market. They were having difficulty getting business in the foreign market because they did not have a Canadian power station which had been designed and built by Canadian General Electric to show the foreign market. In fact, CGE supplied very little of the equipment to the Douglas Point plant, which is our first plant of commercial size.

So I think that the pull-out is quite understandable and quite valid under the circumstances, and, except for the American mar-

ket, I have seen no evidence whatsoever that they are inhibited by the parent corporation.

Senator Grosart: That brings up the second question. The nuclear system that CGE would be interested in is rather different, as I understand it, from the American system.

Dr. Gray: Yes.

Senator Grosart: Would this influence the decision? It would seem to me that here is a decision by one part of the General Electric organization in favour of a foreign type system rather than the Canadian system—not foreign to them, of course. I am not suggesting that.

Dr. Gray: So far as I am aware Canadian General Electric had a completely free hand to develop a system different from the American system so long as they did not lose any money.

Senator Grosart: Have you brought this situation to the attention of Ontario Hydro?

Dr. Gray: Oh, yes, they are fully aware. Ontario Hydro is fully aware of the whole program. I do not know how many Ontario Hydro employees are working side by side with our employees in our Toronto office, but it is like one big engineering organization. It is half Ontario Hydro and half AECL. So they are fully aware of all these points.

Senator Grosart: Does the same situation prevail in Quebec?

Dr. Gray: Do you mean with respect to designs for Hydro Quebec?

Senator Grosart: Does Hydro Quebec have the same purchasing policy as Ontario Hydro?

The Chairman: In terms of dealing with a monopoly, in other words?

Dr. Gray: Yes, Hydro Quebec does have the same policy.

Senator MacKenzie: Mr. Chairman, I have a very brief question in line with Senator Grosart's questions. It has been stated that there is a difference between the Canadian system and the American system. Naturally ours is better, but what is the difference?

The Chairman: That is hardly a brief question, Senator MacKenzie.

Dr. Gray: The main difference is that we use heavy water as a moderating material to slow neutrons down so that they can do their job, whereas the Americans are using ordinary water. This main difference then leads to a lot of other differences. Putting it another way, the main difference is that, because heavy water is a very good moderating material, a very efficient one, and does not capture the neutrons, we can use natural uranium, whereas the Americans have to use enriched uranium to make their system work. This is the fundamental difference. They are both water cooled; they both raise steam at about the same temperature.

Senator MacKenzie: Is there much difference in cost?

The Chairman: Now you are back on the track.

Dr. Gray: The capital cost of the American stations is lower. It is very difficult to compare them because no one has a real knowledge of what their costs are. However, a recent study—it is the most recent study—has just been done for Brazil by the International Atomic Energy Agency. In it they conclude that the Canadian type of plant—I think the 500 megawatt size—would cost $240 a kilowatt, whereas the American type of plant would cost $200 a kilowatt in capital cost. However, the fuel cost is where we have a winner. We are way down in fuel costs. Our fuel costs are something in the order of .7 mills per kilowatt hour and going down; the Americans' fuel costs are 1.4 mills per kilowatt hour and going up. They may come down.

Without low fuel costs, of course, our system would not be acceptable to anybody. But with low fuel costs it turns out that we, under our circumstances, produce lower energy costs. The mills per kilowatt hour are lower from the CANDU system in Ontario Hydro than they would be in a similar American system.

Senator Grosart: Still on this same question, I know from your brief and from other papers that have been prepared by your staff that you have a very great confidence in the competitive future over the long term of the natural uranium/heavy water reaction system. Your brief says that there are nuclear energy plants in 50 countries. Roughly how many plants are there in total in those 50 countries?

Dr. Gray: There must be at least 30 or 40 in the United States alone.

Dr. Lewis: I am afraid I have lost the connection.

Mr. Watson: The total number of atomic energy plants in the whole of the world?

Senator Grosart: I am asking for the total number of nuclear power plants in the world.

Dr. Gray: I would be surprised if we actually said that there were nuclear power plants in 50 countries.

Senator Grosart: I may have misinterpreted what I read. On page 8 of Appendix 6, in paragraph 24, you state that:

> Today some 50 countries have operating nuclear reactors of one type or another.

Dr. Gray: These are research reactors. They are small reactors. Taiwan has a two megawatt reactor, and that is one country. They are producing no power. The only countries that have operating nuclear power stations are the United States—and they have a whole list of them, and that is a big program,—Canada, Germany, France, Italy, England, Spain, Pakistan under construction, India under construction, Japan and Russia. Czechoslovakia is building one.

Senator Grosart: I probably misunderstood the word "operating". I took "operating" to mean operating in the energy field. But of the nuclear reactors now operating, what percentage or what number of them is using the heavy water system?

Dr. Gray: Well, Pakistan and India have heavy water systems.

Senator Grosart: We supplied those. Was that part of External Aid?

Dr. Gray: The one in Pakistan was part of the External Aid program, but the one in India comes under Export Credits. They are borrowing the money. That power program has nothing to do with External Aid. However, they may have some training in it under External Aid.

France has a heavy water plant operating. It is a slightly different type from ours, and they are investigating ours now. The United Kingdom has a heavy water power reactor similar to the one we have in Quebec.

Dr. Lewis: But it is not natural uranium.

Dr. Gray: No, but it is heavy water. Italy has a small one and is developing another like the one we have in Quebec. Japan has a major national program which they call their ATR—Advanced Thermal Reactor—which uses heavy water. It is like our Gentilly reactor with heavy water moderator and boiling light water coolant.

Senator Grosart: I realize it is not possible for you to cover this entire field, and for other reasons, and I emphasize "other", you have decided to stay with the heavy water type. But you say that our competitors in carrying out plans for fast breeder reactors are hoping to overtake us. What is the significance of that marketwise?

Dr. Gray: If the fast breeder reactor works as the designers and proponents expect it to work, you will end up with a very low fuel cost. It ends up with being almost just carrying charges because they produce more than they burn. However, there are a lot of problems ahead for that system, and you get varying estimates even from the proponents as to whether they will have it in commercial use in 1985, 1990 or 1995. If they did not have these problems, or if they succeeded in solving them, it would be a competitor. It is a high capital cost and very low fuel cost plant. If the fast reactor breeder comes off, they will be a competitor, but they have to have reactors like ours to get started, they have to have a lot of plutonium, and we have the best plutonium producer. In fact it is better than all the other reactors. If we stop and if we don't have support for our programs for any reason or if no funds are available, we will be overtaken quickly, because we just cannot sit still. We have got to move ahead. However, we have no evidence of this lack of support.

The Chairman: Are you doing research on breeder reactors?

Dr. Gray: We have no specific programs identified as such. We have done some work on the Intense Neutron Generator which involves liquid metal coolant, which would give us some experience and may well be one of the payoffs from that program even though it has been going on in this way. We may be getting into the edges of fast breeder technology. Up until now we have felt our money was better spent in another field. Fast reactors are not necessary for the Canadian scene.

Dr. Lewis: There is a much more fundamental reason. It costs so much, and we have never been funded on a scale that would come near the fast reactor programs.

Senator Aird: Have you asked for funds?

Dr. Lewis: No, because we think we are competitive in the line in which we are going.

Senator Grosart: Dr. Lewis referred to the "popular" hopes for the viability of the fast breeder reactor. Is this suggesting it is not a scientific hope?

Dr. Lewis: That is a correct interpretation. That is to say the very big expenditure on these programs is intended to make the thing viable and scientifically there is very good reason for having to spend this money. However, it is a very difficult technical program to pull off. This is a very complicated subject, but I think the simple thing we would say is that we do not expect ourselves to be put out of the competition, but it is still a competition and unless we go on with our own design, then of course we would be overtaken.

Dr. Gray: We will be having discussions with the U.S. Atomic Energy Commission—within the next couple of weeks—and among other items to be discussed will be the access of Canada to their fast reactor programs. Whether we will reach an agreement or not is something else. But I don't think that there is any doubt that if we had a real interest and funds—and this will happen some day—to get into this fast reactor program, we could arrange with the United States to get access to many millions of dollars worth of R and D. This is one of the subjects we will be talking about.

Senator Yuzyk: Do fast breeder reactors require new plants?

Dr. Gray: They certainly do.

Senator Yuzyk: It is not merely a variation?

Dr. Gray: No.

Senator Grosart: Assuming you go on on the line you are mentioning, reducing capital costs and increasing efficiency do you expect the heavy water reactor will remain competitive in Canada and in international markets in the foreseeable future?

Dr. Gray: Yes, very much so because the low fuel cost can be a great advantage. It is like having a hydraulic plant with the Ottawa River running through it. If you have a low fuel cost it will be possible for the plant to continue operating, but if you have high fuel cost it will have to close down. I feel such plants have a long life once they are built.

Senator Grosart: How much of the capital cost gap do you think we might be able to close in the foreseeable future?

Dr. Gray: It depends on the optimism of the engineer making the estimate. When you get to a 1,000 megawatt plant, eight or 10 years from now, the cost will be no more than the American cost. I think this is a good target and I hope we will reach it. But I think it will be difficult to close the gap completely. However, when we get into the 1,000 megawatt range, if we can make the progress we hope to make, we will be very close to the unit capital cost of the big American plants. We are well within the British unit capital cost now.

Senator Grosart: What is the present capital cost disparity?

Dr. Gray: In this report, which is as good as anything, they are saying at 500 megawatts ours is $240 a kilowatt, and the American type plant would be $200 per kilowatt. This is, I think, a good estimate.

The Chairman: Would not the implication of all this be that it would be in our interests to build larger stations than the Americans?

Dr. Gray: Yes.

The Chairman: And I am under the impression that the Americans are already building larger power stations than we are.

Dr. Gray: Yes.

The Chairman: Why is that?

Dr. Gray: It really relates to the utility, to the size of the utility. Until now 500 megawatts was all that Ontario Hydro felt they wanted to put in one unit of their system. These double every ten years. It does not take long before they go from 500, to 750, to 1,000 to 1,500 megawatts—about as fast as you can design them. In the American system the facilities are very large, and, TVA were able to take 1,100 megawatts without any trouble; and, of course, there is the competence in building them to a firm price. But I think that within three years we will be starting the design of a 1,000.

Senator Lang: What is the Pickering cost per kilowatt?

Dr. Gray: About $250. It really depends what you put into it. The $250 includes operator training, half the first fuel charge, heavy water, interest during construction, with escalation, it may rise over the $250.

Senator Lang: What is coal by comparison per kilowatt?

Dr. Gray: At a guess, $100, $110 a kilowatt. We could get an accurate figure for you.

The Chairman: Capital cost?

Dr. Gray: Yes, capital cost, and fuel costs are 3 mills per kilowatt hour. This is the only reason we are competing with coal.

Senator Yuzyk: Could you explain the advantages of thorium in the reduction of fuel costs?

Dr. Gray: Sources of energy for the future is one of the reasons the United States is developing fast breeder reactors. They claim that if you just burn uranium you are going to run out of fuel. We think there are other ways of utilizing the fuel rather than a fast breeder. With the CANDU type system, that is the core, the atmosphere in there is very good for burning thorium. If we let the heavy water moderator reactor operate like the Pickering reactor, and if we do that in a boiling regime, I think we have an ideal situation to burn thorium. It happens to be what thorium likes.

In our reactors we can bring it in as a fuel without changing the reactor. Thorium is not fissionable; you have to put in something like Uranium 235 or plutonium.

One of Dr. Lewis' latest theories is a multiple fuel reactor which burns thorium along with plutonium and uranium, and ends up extending the energy reserves far into the future. It is a different solution to the problem of energy reserves from the one the Americans are proposing in the breeder program. Both these will come about. There is no doubt that the breeder reactors are going to be built, and probably they will be successful. I think there is probably no doubt our thorium burner will be built and that it will be successful.

Senator Kinnear: May I ask a supplementary to Senator Lang's question on Nanticoke? I understand they are going to use coal, and it is causing some concern throughout southern Ontario because of the pollution. I understand what you are saying is that a coal-fired plant will cut the cost of operation, probably, in half.

The Chairman: No, the cost of construction.

Senator Kinnear: The capital cost, thank you. What about the pollution area?

Dr. Gray: There is really no pollution from a nuclear plant. The Control Board control it so closely that really pollution is nil. First of all, there are no stack gases that you have from a coal plant—there is no SO_2. We think that the Pickering nuclear plant will be competitive with the coal plant. We think that the unit energy cost will be like Nanticoke. They are cheaper to build, but more expensive to operate. Probably if they added the cost of pollution control into the conventional thermal plant, it would put their cost up another few dollars per kilowatt. Ontario Hydro will have to build some more coal-fired plants for various reasons—to balance its system and have peaking available; and they are well aware of the problem of pollution and the public concern.

Senator Kinnear: Lake Erie is one of the worst polluted of the Great Lakes. They consider that the temperature rise in the water will be about 2 per cent. Is not this going to add to the pollution problem, with the algae we are encountering there all the time?

Dr. Gray: I would not like to pose as an expert in pollution or coal-fired plants. We cannot claim that our plant would not raise the water temperature either. We will try not to locate them on Lake Erie, but put them on Lake Huron, or down lower!

Senator Kinnear: I do not think anything will grow in that cold water.

Senator Yuzyk: What about Hudson Bay?

Senator Grosart: Is this what they call thermal pollution?

Dr. Gray: Yes, this is what they call thermal pollution.

Dr. Lewis: I think this is getting somewhat exaggerated. This is not raising the temperature of Lake Erie. It must be in the vicinity of the plant, in the cooling water.

Senator Grosart: If you could raise the temperature of Lake Ontario you might make it possible to swim in.

The Chairman: Honourable senators, the committee will adjourn now to reassemble at 3.30 this afternoon at which time we will resume our questioning of the witnesses.

The committee adjourned.

AFTERNOON SITTING

(*Second Session*)

—Upon resuming at 3.30 p.m.

The Chairman: Honourable senators, this morning Dr. Gray presented a detailed state-

ment of the activities and plans of his agency, and this was followed by the beginning of the usual question period; we dealt mainly with the marketing prospects for nuclear reactors and other products developed by Atomic Energy both at home and abroad.

This afternoon we will go on with that discussion and deal as well with other aspects of the activities of Atomic Energy of Canada Limited. I would ask Senator Aird to continue with the questions he began to ask this morning.

Senator Aird: Mr. Chairman and Dr. Gray, I would like to take you back, if I may, to the brief. I would like to make reference to page 4, paragraph 11, the first sentence:

> First of all, I have some doubts as to whether the figures reported on R and D in Government are correct, simply because I doubt that accounts are kept that way. Certainly we do not do so in AECL.

Throughout the brief, in addition to this statement, you made continual reference to accounts. That aroused my interest as to the accounting procedures you do follow in AECL. I had an opportunity to study the two most recent annual reports, 1967-68 and 1966-67. I trust that you have these before you, sir, as we have discussed this question informally before the holding of this meeting, inasmuch as I felt that you should have some notice of this kind of question.

I am concerned about the two columns in these reports that refer to the year 1967. Taking the 1967-68 annual report, for instance, under "Operating expenses for science, Chalk River", we find $4,629,115. When we go across to the previous year's statement regarding the same expenditure, we find under "Science, Chalk River" the figure $9,363,824.

In similar fashion, some of these items are changed, but the total is constant, it is $55,494,598 in both cases.

My question to you, sir, does not relate to the propriety of your statement or the fact that it has no doubt been approved by the Auditor General of Canada. What I am concerned about is, who decided on these changes, how did they come about, who determines the allocations? If there is a discrepancy of some kind or another, might I suggest to you that a normal commercial practice would have been to annotate it in some way, so that this could have in effect been spelled out for the public to appreciate? I appreciate that this is an accounting question and not a scientific question but it is the kind of thing we are interested in. We are interested in allocations, we are interested in priorities. Perhaps you would like to take this question under notice?

Dr. Gray: Senator Aird gave me an opportunity to look at this. I did not have the answer right off so I checked with the treasurer of AECL. He assures me that certainly in our accounting field—that is, the Crown corporation accounting field—what is done is correct and should not have a note. The decision as to the form is usually made by the treasurer and by me. What happens is a change of organization, a change of structure, and we end up changing programs. There is no difference in the money, the money was spent in 1967 and we have detailed accounts to show how it was spent. But, when setting up the accounts for 1968 we had a change of organization. He advises me that it is standard accounting practice—in a Crown corporation, at least—that it is a requirement that the two columns be comparable for the content in that particular item. There is no argument about the total, the arithmetic is correct. This relates to each individual item. What the Auditor General requires us to do is that, if we have had a change we do this. If under 1968 we have included under Science $4.7 million we are required to include the same things in 1967 Science, and put an amount in and it does come out to $4.6 million so that you can compare equal with equal. We do not have the same headings in 1967.

The question Senator Aird raises is in relation to putting in a note to explain this. If we did not do it in this way, if we put the regular 1967 items, those we had in 1967, and did not explain it, we would have to put a note in.

Having done it this way—and the treasurer advises that not only is a note not required but it is not good accounting practice. Senator Aird is much more able to decide what is good accounting practice than I am. We will certainly take this under notice and speak to the Auditor General, and perhaps next year we can put a note in.

Mr. Golden: I can assure you that this is going to be looked at, because I sign both of these statements.

Senator Aird: I am not questioning your arithmetic or your honesty. What I am concerned about is disclosure to this committee and to the public of Canada. It may very well be that the decision is that this is not to be done by way of note. I thank you for the compliment to my accounting abilities—but I think that in commercial practice one would lean over backwards to disclose this kind of thing.

I would like to proceed, if we have disposed of that question. I do not want to be petty or picayune in dealing with semantics of your brief but I would like to refer you to the second question on page 6, under Item 16. The second sentence says:

> For example, the U.S. nuclear energy research and development laboratory at Argonne is run by a group of universities co-ordinated by the University of Chicago under contract with the United States Atomic Energy Commission. AECL could enter into contracts with Canadian universities to run its two major research establishments. Then $40-$50 million would promptly be transferred to the heading 'R and D in Universities' from that of 'R and D in Government'.

My presumption is that this suggestion is made without your tongue in your cheek. I do not want to deal with accounting too much, but to bring about results like this simply to change some accounting practice strikes me as being somewhat incongruous. I am sure this is a valid suggestion by you. What I really would like to know is, is it a firm suggestion?

Dr. Gray: No, senator, it is not a suggestion at all. What I am trying to argue is that the method of doing accounting does not really show what is done "in house" as distinct from what is done by contract or elsewhere.

The Chairman: This applies only to your capital expenditure?

Dr. Gray: No. Operating expenditures, very much so. Capital as well. All the equipment that we buy is from operating funds. But, for example, when we contracted for the Whiteshell reactor, and made an expenditure of $10 million which went to Canadian General Electric, that was capital. Generally speaking just as much is spent in this way in operating as in capital. The quantity of expenditure in R and D that is charged to Government laboratories is much more than is done in Government laboratories. A lot is done in industry, some in universities.

Senator Aird: So, this is illustrative?

Dr. Gray: Yes, we are not suggesting that Toronto University take over our operation.

Senator Aird: Again on page 4, paragraph 11, I presume you are making the same point there regarding Whiteshell?

Dr. Gray: Yes.

Senator Aird: If this is the case, who decided that Whiteshell would be so charged?

Dr. Gray: It is in our cost, so the Bureau of Statistics would say it is R and D, if we spend $40 million, including this $10 million all is charged to Government research.

Senator Aird: Have you objected to this inclusion?

Dr. Gray: We have no objection, except that decisions may be made on information that is really not correct. We do not think there is as much "in house" Government work done as the public accounts indicate.

The Chairman: This would apply also to all other agencies.

Dr. Gray: Yes, most other agencies anyway.

The Chairman: Could I for the sake of our procedure go to Senator Grosart and then to Senator MacKenzie?

Dr. Gray: Mr. Chairman, I answered two questions this morning with some reservations. One question was on the cost of a thermal power station relative to a nuclear power station, and I said, roughly, that ours cost around $250 per kilowatt and the thermal cost maybe $100 or $110 per kilowatt. I have been able to get more accurate figures. This is the report to the World Power Conference by Ontario Hydro. Comparable numbers that they have used are that in the Pickering type plant it is $244.7 per kilowatt for nuclear plants as compared to $121.5 for coal-fire plants. It is about half. The coal-fired plant is a little higher than I had predicted.

I discussed this on the phone with Ontario Hydro and they think about $125 per kilowatt, electric, is about right for the present plants, but if they go to super critical coal-fired plants that price will rise to perhaps $240.

Senator Grosart: That is capital?

Dr. Gray: That is capital, yes.

Senator Leonard: Have the Swiss contractors not been tendering the lowest bids on some of these reactors?

Dr. Gray: On turbines I think the answer is yes.

Senator Leonard: But not on the nuclear reactors?

Dr. Gray: The Swiss are not offering nuclear plants.

Senator Leonard: But these are tendered on international plants, on plants in the UK and in the United States.

Dr. Gray: They offer only the turbine end of it.

The other question was asked by someone who wanted to know where all the heavy water plants were located. I have a list here, if anybody is interested in it. There are nine heavy water nuclear power stations in operation around the world. There are another 14 that are committed.

The Chairman: Could you give the full title of that publication, please?

Dr. Gray: Yes. It is Report NOD-2 of the World Power Conference held in Russia in August of this year, entitled Operating Performance and Economics Heavy Water Moderated Nuclear Stations, and it is by the Hydro Electric Power Commission Ontario.

Senator Grosart: Mr. Chairman, I would like to return to the question we were discussing this morning, which relates to the particular system that Canada, through the AECL, has decided to go ahead with rather than adopting the enrichment system or any other system that might be in use in other countries. It seems to me that this is for a Science Policy Committee perhaps the major question that it should satisfy itself on. I am concerned that it might not be long before you are proved wrong. I say "might". It might not be long before you are proved wrong. I base this on comments that have been made by other competent people, and I am sure you know who they are. I would ask you to reassure us as to your positiveness about the course you have decided to take in view of such questions as are raised by, say—

Dr. Gray: May I help you?

Senator Grosart: I think you know whom I mean: Mr. Winnett Boyd, who says quite frankly that you are wrong and that AECL is endangering the whole Canadian scientific investment in nuclear science. Now, he has quite a background in this field. He was with you at one time, I think. He was Chief Mechanical Engineer on the NRU, and so on. Will you give us your answer to his very bald statement that there is a great danger that you are wrong in putting all your nuclear atomic eggs in the heavy water basket?

Dr. Gray: We have known Mr. Boyd for a number of years. He never worked for us directly. He was with the C.D. Howe Company as their Chief Mechanical Designer on the NRU plant. He did a very good job. He is a very able designer. He also did some design work on a system of a high temperature gas reactor that he tried to influence us and many people to buy, or to build, but it did not get built.

I think, to put it really into context, for one Mr. Boyd we have at least 100, if not more, men of equal competence who are on our team and who do not happen to agree with Mr. Boyd.

Whether one man is as good as 100 I do not know. But we are well aware of his system and we have many more chances and opportunities to analyse his system as against ours by our own people and by others. We have access to the British program which is a system somewhat similar to Mr. Boyd's system. There is absolutely no question whatsoever in my mind and in the minds of our senior engineers and scientists that we are on the right line. What is more important to me is that independent people like Ontario Hydro—and they did not get into this blindly—in the very early stages, back when Dick Hearn was Chairman, put their man who is now Chief engineer right into this nuclear power program in 1954 and he was brought up with the whole thing until about 1958 or 1960 when he went back to Ontario Hydro. So that within Ontario Hydro they have a full competence equal to Mr. Boyd's, multiplied many times over, to make their own decision as to what is a good reactor for Ontario Hydro and what is a good nuclear power station.

They have firm price bids from American suppliers. I do not think the British have ever given them a firm price bid, mainly because I don't think the British ever thought they had a chance of winning.

Ontario Hydro is deciding to build this type of plant within their system in very large sizes, and it not only involves very large amounts of money because, when you get 3,000 megawatts in a plant in a system like

Ontario Hydro's, it is much more than money that is involved. It is availability of power. They are making these decisions based on full knowledge not only of our input but of their own input and, to me, this so much more outweighs the opinion of any individual—I do not care who it is, even it if is Dr. Lewis, and he does have some competence.

This is the sort of weight that we put on the decision that has been made to carry on with our type of plant.

Now, what is coming offshore is, of course, equally important. The Australians have been working in nuclear power for 15 years and they have decided that the national program is going to be heavy water natural uranium fuel reactors, and they have a full competence to reach this decision on their own. They are not being led up the garden path by anybody. They have full access to the British program. They have a number of people in the British program. They have fairly full access to our program, that is, to our research and development program. They have people in our establishment.

South Africa is another one. I do not think South Africa's research and development program has anywhere near the depth that Australia's has, but they brought in outside consultants to help them reach a decision.

The reactor that the UK is offering on the open market is a heavy water reactor. They are offering both, but the one we are competing with is the heavy water reactor; the UK is offering that. The French have just now started to become very interested in our type of reactor, and so it goes.

Our board and senior officers are absolutely satisfied that this is the right system for Canada at this time.

Senator Grosart: Speaking of Mr. Boyd, you say his system. Do you identify him with an interest in a competing system?

Dr. Gray: Oh, yes. He designed the system and I understand, according to that paper you have there which I read recently, that he sold it to Arthur D. Little Company. He sold the rights, but he admits that it will never be used. It is 10 years old. There is nothing wrong with it. It is a good design, but in our view it was not a competitive design even at that time.

Now, there is a later version of that which is different. The high temperature gas reactor is being developed in the United States and Europe and it may well become a good reactor system, but this is 15 years after we made the decision, and after we got a major program going.

The decision to go to heavy water reactors was made not when there were a dozen or two boiling light water or pressurized light water reactors being built. The decision was made at the time the nuclear submarine program was getting under way in the United States. We started parallel with them, but the Americans got ahead of us in time owing to the magnitude of their program. But even in retrospect I am sure that all of us who have been closely associated with this would do the same thing again. We wouldn't go off on the enriched light water line.

Senator Grosart: Assuming from the point of view of availability and the other factors you have mentioned that it will be the best system for Ontario and for Canada, is there any possibility that it is not the best system to break into the international market with?

Dr. Gray: We will not get into all areas of the international market. There are many areas in the United States where the system does not fit too well. Where you get a capitalization rate of 14 per cent, as is the case with some of the utilities there, our higher capital cost is not offset entirely by the very low fuel cost. The best thing then is for such utilities to build a lower capital cost plant like BWR. I would imagine the cutoff point would be 10 per cent. The capitalization rate under 10 per cent has a better chance of getting better results from our plant. But the American market is going to be difficult to get into because of the strength of the concerns there like Westinghouse and others. There are one or two areas where we think that our type of plant will be installed.

Senator Grosart: You mentioned this morning a number of very interesting prospects around the world. Do you feel that it would be every bit as competitive with heavy water as with enriched uranium?

Dr. Gray: Yes, very much so.

Senator MacKenzie: I have a question, Mr. Chairman, and my question is very much along the lines of those asked by Senator Grosart. I would like to ask two or three different questions but along the same lines. Who produces your heavy water?

Dr. Gray: At the moment the only production of heavy water, that is the only produc-

tion in quantity, is in the United States. It is much lower now than it was. There are small plants in India and France, and there are two large plants being built in the Maritimes in Canada, but they are not running yet. There is one plant being built at Glace Bay and another at Port Hawkesbury. The plant at Glace Bay is very close to going into production.

Senator MacKenzie: Is there likely to be a market for that heavy water, not only here but so far as other utilities are concerned?

Dr. Gray: If we had heavy water available I could quite easily sell $50 million worth tomorrow. Those two plants have been guaranteed a market by the Government of Canada, and that is presently being taken up by Ontario Hydro. There is no question about a market being available for 12 years.

Senator MacKenzie: If I remember correctly they did produce some heavy water at a plant in Trail during the war. Why did that go out of production?

Dr. Gray: They had a small plant, but it was quite expensive, and it was shut down in the late 1940s.

Senator MacKenzie: I take it it wasn't economic at that time to continue the production.

Dr. Gray: It was a different process and the price was not competitive particularly with the larger plants built in the United States.

Senator MacKenzie: Is one of the reasons we have adopted the practice we have due to the fact that we have available substantial quantities or natural uranium and are not as much interested in enriched uranium as some other people?

Dr. Gray: This is certainly one of the reasons. Enrichment would be available to us from the United States. We have never had any indication that we could not get enrichment from them. In fact we get it all the time for small booster rods for our reactors.

Senator MacKenzie: But we are fairly well placed so far as natural uranium is concerned?

Dr. Gray: We have one of the largest reserves of uranium in the world.

The Chairman: Is it true that we have about 40 per cent of known sources?

Dr. Gray: I don't know the answer, but it is fairly high. Perhaps Dr. Lewis can answer that.

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Dr. Lewis: Below a certain price level, yes, we have about 40 per cent.

Senator MacKenzie: My next question deals with the problem of nuclear waste. If Dr. Laurence were here he could probably answer it. I have long been interested in the methods of dealing with nuclear waste, and how effective those methods are and whether they are likely to pose a serious problem in the future as the number of stations increase, and the amount of waste will probably increase as well.

Dr. Gray: Well, Dr. Laurence will be appearing tomorrow or the next day, if you would like to hold that question until then. However, I would point out that the main waste is inside those fuel bundles, as you will see down on the end table there, and there is no problem in controlling that until you put it through a chemical plant to process it. We don't have a chemical plant yet, but we will have. We have no waste to handle other than the waste we have at the research sites of Chalk River and Whiteshell. There we dispose of it through burial in concrete or stainless steel pits or just in the ground, depending on what is involved. We do a lot of work on this, but we have had no trouble in handling this in Canada at Chalk River and Whiteshell. In the United States, of course, they are handling very large quantities of waste and this becomes part of the cost. It is worked in. It is part of the reprocessing there.

Dr. Lewis: We made a presentation on this to the Third Geneva Conference in 1958, just after we had satisfactorily completed our work to a certain stage. The estimate of the cost of this process on a large scale was .01 mills per kilowatt hour. Now although this may seem a very small figure, it is nevertheless significant when you talk about 20 million kilowatts which we will be doing some time from now, but it has not in fact necessitated that we should do any more work. The situation in the United Kingdom is very parallel. They have also developed a very similar system and it is in abeyance because it is a very low cost system and at the present time there is more interest in keeping the fission products available rather than locking them up and disposing of them. Now, of course, in the United States they have got everything—all kinds of processes.

Senator MacKenzie: Are some of the users of the nuclear material still disposing of the waste in the ocean?

Dr. Lewis: Not on a large scale, no. The difficulty here is that the word "radioactivity" covers such a very wide range. The biggest disposition of radioactivity into the oceans has happened from the explosions of H-bombs. And that is so large compared with the kind of waste that has been put into the oceans otherwise, that there is quite a difference in the order of magnitude. The concern about putting waste into the ocean is to ensure that the materials are properly dispersed. From the H-bombs it was very well dispersed. It either had to be contained or dispersed, and these are the problems that are continuing to exercise the regulating people. But this is not dealing with the main radioactive waste from nuclear power at all.

Senator MacKenzie: Mr. Chairman, if it is in order before we finish our session, I would be very grateful to Dr. Gray or Dr. Lewis if we could learn more about their views on the functions and responsibilities of the universities in respect of this whole development.

The Chairman: Before they answer this question, I know Senator Cameron has a similar question and perhaps he would like to ask that question now so that we might have a broader discussion.

Senator MacKenzie: As long as it is not forgotten.

Senator Robichaud: I had a supplementary question relating to the information which has been given. Reference has been made to the production of heavy water particularly in two plants now under construction in the Maritimes. My understanding, and I may be corrected if I am wrong on this, is that there was a target for the Glace Bay plant to go into production. Can we get any further information on this? Can we find out when it will be in production? I understand it has been under construction for a long period of time.

Dr. Gray: Depending on what target you are talking about, senator—if you are talking about the original target date or the one we have now—if I were to give you the original one I would have to try to explain the delay, and we have nothing to do with the plants.

I was down there last week. We are told it is about four to six weeks to start up and this start-up period has stayed constant. AECL is trying now to help. We dispatched three senior technical officers down there this morning to try to get the plant on line. They have some major problems and a very large investment. I would hope that within a month we will be clearer as to when there will be a real start. But you are quite right, we are going to suffer in AECL and in the nuclear power program in Canada.

The other plant, at Port Hawkesbury, is pretty well on schedule and is to come into production in October of next year.

Senator Thompson: Are you satisfied with both national and provincial legislation with respect to wastage in the handling of nuclear fuel?

Dr. Gray: I suggest you leave that to the Atomic Energy Control Board. I understand they are appearing tomorrow.

The Chairman: During the second week of November.

Dr. Gray: This is outside our responsibility and you will get a better answer from them.

Senator Cameron: In reading your brief and supplementary material it is obvious that there are three major agencies concerned with this whole matter of research and development—the federal Government, the universities, and private industry.

It is obvious from your brief that the costs in the next ten to fifteen years, relative to today, will be up in the stratosphere. That suggests that this committee, as the committee charged with recommending policy to the Government, must come up with some ideas on effective mobilization of our total resources to achieve the desired result.

Have any formal steps been taken to lay out a program or an authority which would co-ordinate and mobilize the research of Government, universities and private industry? Or can this be done?

Dr. Gray: As far as I am aware nothing has been done. When you refer to the cost of research going into the stratosphere, I take it you are not talking about the money available to AECL.

Senator Cameron: I am talking about the cost of providing research and plants, this whole development of new technology in relation to power.

Dr. Gray: The only organization trying to tackle this is the Science Council and they have just issued a first really definitive report, yesterday or today. It will be interesting to see what happens with this report. They have made some fairly positive suggestions of programs they think should be start-

ed immediately, very large programs, and some that should be considered. Within the Government organization, how this is to be handled from that point on is not clear to me.

We have our influence but we have no responsibility. I do not know how much influence we have in the overall planning. In our own program we try to plan at least five years ahead and generally to have this forwarded to the Government every year, indicating what we think should be done to keep atomic energy programs viable. But we do not know how this is co-ordinated with other programs of NRC and other Government departments or agencies—other than the Treasury Board, the procedure of which we understand.

Senator Cameron: What do you see as the role of universities in the future in this picture?

Dr. Gray: Everyone seems to think that only the universities can do this research. I do not agree with that.

The Chairman: Especially Senator MacKenzie.

Senator MacKenzie: If I might defend myself—in my experience those institutions which have had help from the NRC, for instance, have done much better in terms of meeting requirements of Government and industry, in both the work they should do and more particularly in the men and women equipped to go into Government service, than those departments which were lacking in that support.

Dr. Gray: There is no question about that.

Senator MacKenzie: I could cite the departments—physics is one— that have been well assisted and I think we have had results from it.

Dr. Gray: Undoubtedly more research should be done and will be done in universities, but the popular theme now is that the only place to do the research is in the university.

Senator MacKenzie: That is nonsense.

Dr. Gray: That is what I was trying to say here. There will be big research in universities and once they get to the big accelerators and are spending $3 million a year in their operation, they will need an organization for that purpose, like that of Whiteshell or Chalk River, though these are very large. Once you have an institute, the management is quite different from the research you were brought up on. This should be recognized and plans made for it. I think we should have some institutes associated with universities.

Senator MacKenzie: No one has mentioned ING.

The Chairman: We will come to that later.

—Recess.

Upon resuming:

The Chairman: Order please. We will hear Senator Cameron.

Senator Cameron: Arising out of Dr. Gray's answer about the co-ordinating organization authority, the suggestion has come that maybe the Science Council could do this. They can be helpful, but they have no authority and the point I am getting at is that we will probably have to set up a national authority which will be responsible for co-ordinating not only the research but how the production goes. In other words, it would be the marriage of Government, universities and private enterprise in developing a total program for Canada. That is the crux of the thing.

The second question is can we seriously consider a situation in which the governments plus universities will not have the major responsibility for planning and carrying out research and development? This relates to the other question.

Dr. Gray: Not in the immediate future. Perhaps when we are as big as the United States and have companies as big as theirs, this may be feasible, but I think under our present circumstances the Government has to be deeply involved not only in its own operations but in support of research in the universities and some support of research in industry. We find in our work in industry that we have to take an intimate position with industry in order to get results.

Senator MacKenzie: I have a supplementary question, sir. If I may ask you or perhaps Senator Aird whether the prospects of what they describe as the International Corporation are going to affect this situation in the sense that we might get a lot of research concentrated in one industry that might do that research not only for the United States or for Canada, because we have subsidiaries here, but for a good part of the western world at least. And when I say the "western world" I mean the non-Communist world. Perhaps this is outside the scope of this committee.

Dr. Gray: I am not aware of these international agencies that are going to do this. We find that, for instance, General Electric and Westinghouse are doing tremendous programs in the United States in many fields, not just nuclear. The results, I understand, are generally available to the Canadian General Electric and Canadian Westinghouse companies, but by the time they get them and get them put into production the United States are well ahead in the market. It is awfully hard to use research and development that is a couple of years old and has been done some place else. I think you have to have it intimately related with the people who are going to do it right from the basic research straight through. You cannot put this all in little packages and expect to buy your way in.

Senator MacKenzie: This concept of the International Corporation has come up more in the area of finance at the moment, I think, than in the area of research or development or manufacture.

Dr. Gray: If it will make more money available to us, I am all for it.

Senator MacKenzie: You do not care where it comes from.

Dr. Gray: No.

Senator Aird: I have a supplementary question not in answer to Senator MacKenzie's question but referring to Dr. Gray's brief, page 8. Just on this point, you make the statement:

> Support of work in industry that is not related to a Government programme is difficult to justify...

and you carry on. I do not want to take it out of context, but it seems to me that that is a very strong statement. I would like to have any comments you care to make about that.

The Chairman: I think you should read the full sentence.

Senator Aird: All right:

> Support of work in industry that is not related to a Government programme is difficult to justify and unless our industries take some initiative to implement programmes they feel are important to their future and to support them technically, personally and, to some extent, financially, all the Government support in the world for "industrial research" will be an exercise in futility.

Dr. Gray: From our experience we really feel that unless you can get some real input from industry other than taking money and spending it, to give money to industry just to spend on a program not related to Government objectives, to give to company "A" a million dollars a year so they can do research and development,—I do not think that will produce much in the way of results. If they will match it equally or in any formula you want to use, then it starts to become really worth-while.

Canada has a number of programs like this under way and it is starting to have pretty good results. But unless you get industry participating right from top management down, just giving them money is not going to produce any results.

Senator Aird: I note with interest that you changed the word "program" to "objective" when discussing this verbally just now. Perhaps that is my misinterpretation. My interpretation, when I read this, is that it was Government programs. When you just discussed this a moment ago you said Government objectives. The kind of thing that occurred to me when I was reading the brief was, "What about the paper industry?" It is not related to a Government program in any way. What would be your view on assistance there in research and development?

Dr. Gray: I would have thought the paper industry was quite able to look after itself. So far as I know they do to some extent.

The Chairman: Except that we paid for their laboratories in Montreal.

Dr. Gray: In Montreal?

The Chairman: Yes. I remember I was a civil servant at that time in Northern Affairs.

Dr. Gray: It is part of the whole forestry field. That is not really federal, anyway, but maybe the word "program" is wrong. Perhaps "objective" is what we should use. I think we have to take a hard look at the situation in order to justify support in the paper industry. The use of forest products might justify it.

Senator Aird: Immediately, pollution occurs to me, which is one of our Government objectives, no doubt.

Dr. Gray: Yes. Again you can do a lot in research for pollution, but you can do a lot more by regulation.

Senator Aird: Thank you.

Senator Cameron: It is really a peripheral question to the whole project. You remember the row about the Columbia River development? Building dams and getting money in from the United States? In talking to the chairman of the B.C. Hydro, I learned from him something which you confirmed this morning, that by 1975-80 most of the plants will be nuclear plants. "We might as well take this $300 million from the United States now and get it, because hydro power will be a dead issue by 1975 or 1980." That is what he said. Now, the implications of that relate to another of our great resources. We have been spending hundreds of millions of dollars on water control, and we are going to have to spend more. Now, is the development of the nuclear power for production of electric energy going to mean that in the building of dams for water control the first priority will simply be the conservation of water resources or the control of water resources and the power that comes out of that will be a secondary thing?

Dr. Gray: I would think that if you can build a dam structure for water control and pay for any part of it, assign any part of the cost to water control, you will find it well pays you to put in a turbine and generator. What we are really saying is that all good hydraulic sites should be developed because it gives you an energy resource into the future. The trouble is that some of them are a little far away, and if you have to build five or six hundred miles of transmission line with all the problems attendant on that, then you have got to take a very hard look at the cost.

Ontario water resources are really too far away now. Quebec's are getting pretty far away. B.C. still has a fair amount. I think the Columbia was a good thing. I don't think nuclear reactors would have been competitive in the Columbia situation anyway.

Senator Cameron: Does this imply, though, that from 1975 on the determination to build a dam will be influenced more by its water control than by the production of electric energy?

Dr. Gray: Certainly more than it has in the past at least. But it will depend really on the site and the economics. What nuclear power has to offer is low power in the future that was not there previously from all thermal sources.

Senator MacKenzie: And you can put it on the site.

Dr. Gray: Yes, you can put it where you want.

Dr. Lewis: May I add one point that is quite important, Mr. Chairman? Nuclear power is very well supplemented by stored water so that the type of development of water that goes in conjunction with nuclear is a little different but it is very important in getting the over-all cost of power low. The two things should be developed together, with that in mind.

Dr. Gray: I think some required reading might be this report by the National Energy Board, which talks about using pumped storage, that is, a combination of hydro power and nuclear power. Incidentally, this is a very good story that actually has nothing to do with AECL, but it was in the list of suggested background information. If anyone is interested in this aspect of it, this is a very good paper.

Senator Lang: Mr. Chairman, there were two matters touched on in Dr. Gray's brief to which we should perhaps give rather more attention in committee and which we have dealt with before particularly when the National Research Council was before us a few days ago. I also think it was dealt with from my own perusal of the report of the Science Council in the paper this morning. I refer to page 10 of the brief where Dr. Gray says:

> I have been trying to point out in the last few minutes that, particularly with limited budgets, it is important that we should see that good research and development is done in the right fields as efficiently as possible by the best people—and not get carried away by popular slogans. There are circumstances where even applied R and D is better done in government-operated facilities than in industry.

I would gather from that, and I would like your comments on this, that it is a public slogan of today that the Government better get out of R and D and see that more and more R and D is carried out in the universities and in industry.

Dr. Gray: That is correct.

Senator Lang: Is that not flying in the face of the Science Council's report as I read it?

Dr. Gray: It would seem to, particularly in view of the statements of the council. Howev-

er, the report was not written in the way I would have written it.

Senator Lang: Could you give us the pros and cons?

Dr. Gray: If you read the Science Council's report through you will find that they are implying that all increases in fundamental research should go to the universities; this is not possible or practical in our era. If you know all the people on the Science Council, you will realize that is not what all are saying. They are saying that we have to get more of it into universities. The way I read it is that they want to get all of the fundamental work into the universities.

Similarly, everybody is saying we must get all applied R and D into industry. But that is not easy. It is not easy to do research or development in Canadian industry. We put $6 million or $7 million worth of work into Canadian industry, and we have done this for 10 or 15 years, and we are working with our best Canadian companies, and it is hard work to get good results out of Canadian industry. It is not bad if you can get a program of a million dollars a year in a company to carry it through for a number of years because then it gets going and works pretty much on its own. But if you are looking for something involving about $100,000, well then it costs the $100,000 to spend it. When we have tight budgets we have to take a good look at where the money should be spent and by whom.

Senator Lang: Do you think we have been too heavily oriented toward R & D in government in the past as compared with the other two sectors?

Dr. Gray: I don't think we are suffering up to now. We have got to get more R & D into industry and we've got to get more research into universities. But don't put all the fundamental work into universities, and don't put all applied research and development into industry. There is still a requirement for involvement of government facilities, particularly if government money is involved.

Senator Lang: The other point in your brief is referred to on page 12.

Senator Grosart: May I ask a question on that? Would you care to comment on the Orr figures—I am sure you know what I mean—the brief put out by Mr. Orr on this very subject of the distribution of R & D funds as between government, industry and universities. In 1965 in terms of percentage he found that the figure was 36 per cent government, 42 per cent industry, and 21 per cent on what he calls higher education. Does that from your point of view look like a reasonable distribution, if you can have a science policy in this area?

Dr. Gray: I would really like to think about that for a while. I would think we are going to have a higher percentage in both industry and universities and lower in government. As time goes on there will not be an increase in government, but there will be an increase in those other two factors. That would be my guess and it probably would be the right way to do it.

Senator Lang: The other question is referred to on page 12 of your brief, and in this I am trying to draw you into the field of education. At the bottom of the page you say:

> How will we employ our future professional manpower in performing worthwhile jobs in fields in which they have been trained? Are they being trained in the disciplines most needed to do the work of the highest priorities? Are we planning to train too many professionals with advanced degrees?

We have had evidence before this committee that within a few years the number of PhDs graduating will be far in excess of what our facilities can absorb, and that our emphasis has been too much in this area, rather than producing ordinary engineers, who are badly needed in the less sophisticated areas of science. It has been suggested that we should reverse our thinking in this area and that particularly this thinking should be revised in governmental agencies where a high proportion of these men are going and doing post-graduate and post-doctorate work. I know you put this in your brief and it rather poses a question similar to which comes first, the chicken or the egg, but I wonder if you would be prepared to give us your personal point of view in connection with this matter.

The Chairman: Before you do that, could I add a supplementary to this? It seems to me from the information we got from the National Research Council that in a way the system of assistance in the field of training programs of the National Research Council is a main contributor to this possible surplus, so that if we on the other hand, government agencies, produce a surplus, then we have to look for

research projects to employ them and to use the surplus. It doesn't seem to me to be very good policy.

Dr. Gray: I think everybody is contributing to the problem. The provinces are treating the universities very well, we are getting beautiful new buildings, and encouraging everybody to get advanced degrees. It is all part of this whole education scheme. I think the direct assistance to universities from the provinces, and I am sure the federal Government is involved in this in some way, is much greater when you look at the new universities. According to the National Research Council brief they indicate that in 1973 there will be 2,000 PhDs graduating. Most will be employed by the universities. But I would hate to think that what we are doing is teaching people to go back to university to teach people to go back to university to teach people. However, that would be the main employment of the higher educated scientists but not so much engineers. Just to give you a little of the background of this field, we are one of the big R & D employers in Canada, and we will employ maybe 200 PhDs. Now when you think of 2,000 coming out in one year unless the majority are employed in the universities there seems to be no thought given as to how we are going to use these young people, and they are good young people. And unless we give some thought as to what is going to happen, not only to these young people but to other young people we are educating, they are going to be a very unhappy lot. I think we may be building up trouble ahead for a few years.

Senator Grosart: Do you think we should have a Government science policy rather than an NRC science policy, a Defence Research Board science policy and an AECL science policy, or should there be one policy directing funds into these various fields?

Dr. Gray: That would be a nice policy to have. We are not involved in education, but we take as many young people with a PhD degree as our equipment and facilities will allow. We have a dozen or so doing their theses at two of our sites. But we are not in the granting business at all.

Senator Grosart: No. You are in the business of getting answers in finite time.

Dr. Gray: We try. As to the number of educated scientists and engineers who will come out of the pipe line, how are they to be gainfully employed—the NRC indication is related to Ph.D.'s but this is only a small part of the problem.

The Chairman: I read an article by Professor Weir of the Californian Institute of Technology. He is a great expert on the need for scientists in the United States. He says their need is different and he forecasts there will be a great scarcity in the U.S in the coming year. Why is there a difference?

Dr. Gray: The space program probably eats it up. I think he is talking of the year 2000.

The Chairman: The discrepancy or gap has already started, according to his information.

Dr. Gray: We might be completely wrong but we do not see the answers at all and we just raise the question so that you may note it. In our operations every year we send a group to recruit university students. I am not sure that next year we will do that at all. We have not the requirements and people are coming to us asking for jobs. We may not need to go out to the universities. This is an indication of the trend.

Senator MacKenzie: This trend is developing.

Senator Aird: But this is the first time it has happened to you?

Dr. Gray: Yes, for two reasons—availability of people, and cutback in budgets.

Senator Lang: I hope Dow Chemical find themselves in the same position next year.

Dr. Gray: It would give you a little freedom on the campus.

Senator Lang: To avoid undue disturbance of the peace.

Senator Cameron: Should we extend our reference to this matter of cost?

The Chairman: It is in our terms of reference.

Senator Cameron: We should try to project what the demand is likely to be.

The Chairman: In the United States they are developing a program in educational research to forecast the market for the 1970s and 1980s. Do we have such an operation here?

Dr. Gray: I am not aware of it. Even in our own organization we do not know our expenditure for 1975 or even 1972. Recently we have not been good at forecasting, mainly because we have the work to do but the money is not available. We could forecast a

12 to 14 per cent increase per year, which we could handle very nicely and which would be good for the country, and we would employ another 8 or 10 per cent more per year, and it is in a good technical field. This would be a very good thing to do and would help to show how we are to find employment for these young people but we are not getting any increases and this is one of the reasons, it brings us up short.

Dr. Lewis: We are quite a small organization compared to that in the United States. There is a difference. We have a parallel mission oriented research and development. They are able to employ large numbers of people but while we are mission oriented we are very small.

Senator Leonard: Does this situation relate both to physicists and to engineers, in regard to departments for which Ph.D.s are being turned out?

Dr. Gray: The problem is probably the same. In AECL we have a little more freedom in hiring engineers, because of the work we are doing in nuclear design field. All that is being paid for by Ontario Hydro, Hydro Quebec, and India.

We could increase by 100 people in our Toronto operation without trouble as it is paid for. It is in the research operation and the science end that it levels out. In a small group like ours, it takes only a small number of scientists—physicists, biologists and chemists—the engineers will be a little freer because of the nuclear power program.

Senator Thompson: Is there any period after which the productivity of scientists stops? It was suggested that younger people coming in have new knowledge and a new approach and would be more productive until about age 35.

Dr. Gray: We have nothing on this whatever, and Dr. Lewis is still pretty productive.

Dr. Lewis: On the other hand I would regard this as a very necessary part of management of a research establishment. I do not want anyone on the staff at age 40 unless he is regarded as a senior scientist, that is to say, he has to be productive at age 40 to be kept on and this causes a bit of deliberate attrition, that is to say, one is moved over off the real R and D by then.

Dr. Gray: If they are not any good as scientists, they are put into management.

The Chairman: Someone said the other day that an engineering graduate finds that after ten years, 50 per cent of his knowledge is obsolete and 50 per cent that he will need to know for the future will not have been discovered yet. Do you have any plans to retrain scientists at age 40?

Dr. Lewis: It is a matter of moving them into other occupations, and this happens.

Dr. Gray: In the science and engineering field, what they have learned ten years ago is half obsolete. But they keep up with the literature and designs and programs, in their field of undertaking, and these are the people who are producing the new information. We do have retraining programs—at all levels except mine.

Senator Yuzyk: On the application of atomic energy, we have been discussing the production of power. You must be looking into various applications where such a large scale operation might not be necessary. A smaller scale might be used in industry. Are you doing research in that direction?

Dr. Gray: We have had a number of programs over the years. If you are thinking of just nuclear power, it is used as a thermal heat source for a process of some kind or as a method of producing electrical energy for processes. We completed a fairly large study, partly "in house" and partly by consultants—largely by consultants—to take a look at the market for small power stations. These would be small power stations of one megawatt up. Then we would see whether we could meet that market. We have concluded that we could not meet the market with the systems that we know of now. We concluded that in the small northern establishments, or for individual companies, it does not look as though these small systems would be an economic proposition. You really have to have a fairly large complex to make it economic.

At the other end of the scale, however, there are these large complexes being thought of comprising reactors of several thousand megawatts at one site as an energy centre or an agro-industrial complex for developing nations, or even for Los Angeles water, and at the top end of the scale it looks like a very diverse use of this low cost energy both as thermal energy for desalting and processing and electric energy for running these plants.

The one of this type that looks closest to being applied is in India. Dr. Sarabhai, Chairman of the Indian Department of Atomic Energy, announced last month that they are

proposing to put two 600 megawatt reactors together, and this is much bigger than they have ever done before at one site, as an energy centre to do irrigation and to make fertilizers and to do some other processing work. So that there is quite a large area of application in both the big sizes and the small sizes, except that in the small sizes we are restricted to the use of isotopes for power sources. I do not think we are likely to see nuclear power used in the small sizes.

I do not know whether you want to augment that or not, Dr. Lewis.

Dr. Lewis: The question might not have been confined to power. There are other uses for isotopes. All these irradiation applications are involved, and there is one under study which might be significant, and it is mentioned in this brief. It is the application to irradiation of sewage as a means of chemical control. It helps the precipitation. But it is quite undertermined at the present time whether cobalt 60 or some other form of radiation would be used for this purpose.

Dr. Gray: There is quite a broad field of application of radiation in processes and in the medical field and so on.

Senator Yuzyk: Can it be brought down to smaller units, say, where people dream about the possibility of atomic energy being used to power automobiles, for instance, or airplanes?

Dr. Gray: Perhaps airplanes.

Mr. Golden: If money is no object, sure.

Dr. Gray: But we are not living in a world where money is no object.

Mr. Golden: We do not want to leave on the record the suggestion that it cannot be done or is not being done. A country to the south of us is spending enormous sums on this for reasons other than economy. It is being done for military purposes.

Dr. Gray: Yes, the nuclear submarine is one splendid example. It has a small engine of tremendous power and has done more to finish off war than any other deterrent. The nuclear sub is a tremendous deterrent. But it is, from an economical point of view very, very costly. Or perhaps even on an economic basis it is a good thing. If it stops war, it is worth-while, but it is not inexpensive. You could not operate industry with a reactor of that type.

Senator Cameron: This morning, in aswering some of Senator Aird's questions, you referred to where nuclear reactors were being built, and you mentioned arrangements to build one in China. I am curious to know what size and where. Is this part of Canada's expanding trade pattern?

The Chairman: What China?

Senator Cameron: There is only one China; the other is the Taiwan clique.

Mr. Golden: In that case it is the Taiwan clique.

Dr. Gray: It is Taiwan.

Senator Lang: Senator Cameron is an independent. He does not reflect Government policy.

Senator Grosart: I think it should go on record, Mr. Chairman, that some of us think that there is more than one China.

Senator Cameron: I was curious to know whether it was in mainland China.

Dr. Gray: It is in Taiwan, and they would like to get started and would like a research reactor like the one we built for India. It is quite a sizeable plant, running into some tens of millions of dollars, and discussions are very active at the moment.

The Chairman: I would hope that, contrary to what we did in India, we would put some conditions on this arrangement.

Dr. Gray: I think this one is fully covered sir.

Senator Grosart: I have a few questions for clarification purposes. You say that in the next 20 years Canada's total expenditures will be in the order of \$4 billion to \$5 billion on atomic or nuclear development generally. Is this the total Canadian picture?

The Chairman: What page is that on, senator?

Senator Grosart: It is Appendix 2, page 1.

Dr. Gray: The number is about right. I am sorry, senator, was the question whether this was all Canadian?

Senator Grosart: My question is is this a Government expenditure?

Dr. Gray: None of it.

The Chairman: This is utility.

Dr. Gray: It is utility expenditure. I would say that it is not Government expenditure at all. There would be some Government expenditures on top of that, related to research and development, but the Ontario program, as I mentioned earlier, is now entirely utility

expenditure. In the nuclear end of the plant it is at least 80 per cent Canadian content. It is probably more than that. There are only two or three parts that are not using Canadian material, and that is because it involves some special tubing, pressure tubes, which we are not yet able to get manufactured in Canada. There are such items as pumps and valves as well. But with respect to all major parts of the nuclear portion of the plant bids are invited only from Canadian suppliers. With respect to the remainder of the plant, the turbo generators, the condensers and so on, I think the utilities are likely to call world bids.

Senator Grosart: If I read your tables 1A and 2A correctly, in the 25 years that you have been in business in AECL, you have spent $612 million. Is that correct, just roughly?

Dr. Gray: I did not add it up, but that sounds about right.

Senator Grosart: What percentage of the total Canadian expenditure on nuclear development would that be, roughly?

Dr. Gray: Ninety-nine per cent.

Senator Grosart: Yes?

Dr. Gray: Maybe not quite 99.

Dr. Lewis: It depends on what one is including in nuclear development. If one is taking this in conjunction with the cost of stations that are built, then you can point out that Douglas Point is $89 million. That is the largest one actually built. And the Pickering stations are $250 million.

Mr. Golden: That is not the question that was asked.

Dr. Gray: I think the question concerns the development cost, which is roughly $600 million. You are wondering if that is matched in any way by industry or by the universities.

Senator Grosart: Or the utilities and so on. You think this is something in the order of 99 per cent of Canada's total expenditure.

Dr. Gray: I would think so, yes.

Senator Grosart: So in money terms, industry is contributing nothing. In money terms, industry has made no contribution over this 25-year period.

Dr. Gray: Canadian General Electric will argue that they have contributed. They contributed $2 million to the NPD plant, but they then supplied it on a cost basis. I think they might argue that they have an investment of $2 million or $3 million that has not been paid out in selling the product to us, but outside of that all of our development contracts, our $6 million or $7 million a year, is totally federal Government money not matched in any way by industry. That includes their costs plus their overheads. So I think the 99 per cent is correct. I will check with our treasurer or some of our people on that, but I think that is a pretty good guess.

Senator Grosart: On another point, Dr. Gray, you say in the brief that by 1988 you presume about one-quarter of the total of our power energy capacity will be nuclear. That is a bit lower than the Americans. I think their estimate is one-third by 1980 which is understandable. How will that compare with the rest of the world, however, by 1988?

Dr. Gray: I think in the United Kingdom the percentage will be higher than that for nuclear. France and Italy are just getting going now, but they will move up very quickly. I would think that the Canadian percentage is probably about right. It may be a little low relatively for a lot of the European countries.

Senator Grosart: Is this because we have other available power?

Dr. Gray: A large part of our country, the prairies and British Columbia, still has other sources that are more economic than the nuclear source.

Senator Lang: I just want to ask Dr. Gray a question. It may be an unfair question or one that he cannot answer. I rather expect it might be both, but I do not know who else to ask this question of. Canada is now prepared to sell uranium or plutonium to France for peaceful nuclear purposes. Can Canada sell uranium or plutonium to other countries for peaceful purposes and assure that it is so used, and assure that in so doing they are not thereby just releasing other supplies that might normally be required for useful purposes for purposes of a military nature?

Dr. Gray: I think I can answer that, and it is not embarrassing. When we supply plant or uranium or plutonium from Canada to France or any other country it is done under an agreement that involves what we call safeguards. Up until now we have had a number of bilateral arrangements, and I think the policy now is to have the Government require International Atomic Energy Agency officers inspecting the use of the uranium or plutonium or the plant to assure themselves that it is

being used for peaceful purposes only. Dr. Laurence can tell you more about that because he is in charge of this area. He has inspectors going around in other countries inspecting what we have done in India and Germany and he will also be going to France to inspect what is being done with the material there. Of course you have the situation that once you supply, say, a ton of uranium to country "A" which already has a supply of uranium all its own, you automatically release that material for any purpose they wish to use it for, and you have no control over it. However, if the NPT—the Non Proliferation Treaty—comes into effect and all facilities are subject to international agency inspection as are nuclear power stations, then there will be total control. That is what we are looking forward to and we hope that it will come about. It is really the best way of doing this.

Senator Lang: If and until we do have such a treaty isn't the supplying of uranium for peaceful purposes just a bit of a mirage since it releases an equivalent amount for other purposes?

Dr. Gray: If the country concerned has other sources of material, yes, but if you don't have other sources, then you are all right.

The Chairman: Isn't India a very good example of that?

Dr. Gray: The plants we are building for India now are under full control, but there we have done a very good thing for India in that we have helped her to get into the position where she can build her own plant as she is now capable of doing. India is building two more plants near Madras to their own design and under their own management and presumably they will be able to get the equipment either within their own country or elsewhere and they won't require safeguards. I would suspect that they will end up by having two large nuclear power stations built within India without safeguards. So there we have done two things; we have assisted a developing country onto its own feet, and we have aided them to have a reactor that is not safeguarded. But we have to take the good with the bad.

Senator Aird: Since the invasion of Czechoslovakia it seems to be a common opinion that the hopes for the nonproliferation treaty are somewhat more remote. Would you care to comment on that?

Dr. Gray: We have no competence at all to discuss whether the NPT will be accepted at all, nor do we have any view as to whether the invasion of Czechoslovakia changed this very much. But Czechoslovalia has agreed to accept International Atomic Energy Safeguards as has Romania. We would not be even talking to any of these countries unless we were sure that there would be an intergovernmental agreement—a trilateral agreement between Canada and the Government and the Agency.

Mr. Golden: We of course don't make these decisions. The Government of Canada tells us what it wants done.

The Chairman: Any other questions?

Senator Desruisseaux: I wonder if the question I wish to ask has been answered before. I must excuse myself for my absence. The supply of uranium which Canada has will obviously die out sometime in the future, but is it foreseeable when we will have an end to our supply?

Dr. Gray: Certainly the known reserves will run out towards, I suppose, the end of the century. They will not run out related to the Canadian program. They will run out due to the use and export of uranium. Enough Canadian uranium is now discovered to handle the Canadian program for a long time. I think you would get a better answer from Mr. Gilchrist of Eldorado, as to what he feels the uranium reserves are like.

The Chairman: I presume that would also be assuming that the breeder reactor does not become practical?

Dr. Gray: No, even with the breeders. It relates to price.

The Chairman: Could we meet again then at 10 o'clock tomorrow morning?

Dr. Gray: Yes, sir.

The Chairman: I still have a few questions and then we will go to the ING question.

Dr. Gray: We can answer that in two minutes now, if you like.

The Chairman: It might last for an hour with the other questions.

Dr. Gray: I think the answer is pretty straightforward.

The committee adjourned.

MORNING SITTING

(Third and final session)

Thursday, October 31, 1968.

The Special Committee on Science Policy met this day at 10.00 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, continuing our meeting of yesterday, we are pleased to have with us again the representatives of Atomic Energy of Canada Limited. I have some questions to ask.

If I understood you well yesterday, Dr. Gray, you are planning for the immediate future in terms of research, to try as much as possible to improve your heavy water reactor, and this is going to be your main research effort. You are not planning, at this stage at least, to devote too much time and energy to the breeder reactors?

DR. JAMES L. GRAY, PRESIDENT, ATOMIC ENERGY OF CANADA LIMITED: That is correct. We have two programs. One is to make sure that the present primary reactor is really good, but that work is dropping off and the work of improving the reactor which is an advanced version of the present one, is building up. Those two take up most of our applied work.

In the science side, which is mainly Dr. Lewis' area, the scientists are looking at newer versions of reactors—which is maybe eight to ten years away. That program could start to come in at any time, but it will build up slowly.

The main R and D program is making sure the present type of reactor now being built in Canada and elsewhere is on a very solid basis and remains on a solid basis, and then we improve that.

The Chairman: I understood yesterday that Dr. Lewis did not have too much confidence, at least for the immediate future, in breeder reactors.

DR. W. B. LEWIS, VICE-PRESIDENT (SCIENCE), ATOMIC ENERGY OF CANADA LIMITED: That is correct, as far as the fast breeder reactor goes it is of course the one that is nearest. I am merely suggesting that it does not remove us from the competition. We can compete with it when it comes and I am not expecting difficulty there.

The Chairman: Would it be a complement?

Dr. Lewis: Yes, in a sence, as Dr. Gray has mentioned, they require plutonium and one of the best methods of producing plutonium is in CANDU. It helps CANDU to use its fuel, because of the plutonium in it.

The Chairman: What about nuclear fusion?

Dr. Lewis: Everyone would say that is still beyond the horizon. It is a very active topic in many nations of the world but no one has come close to suggesting an economic device.

The Chairman: Is the research effort on this, which is being carried on now, mainly being done by the United States?

Dr. Lewis: Oh no. In Russia and Germany and many other countries they are involved, and the United Kingdom still has its Culham laboratory, even though they have reduced it in size, it is still a powerful program.

The Chairman: I noted also you are doing research in physics, biology, and medicine. In regard to physics, how do you proceed to avoid undesirable duplication with, say, the NRC or the Medical Research Council or similar agencies?

Dr. Gray: In regard to the Medical Research Council, we have really no program in medical research. In the biology side we have some at Whiteshell in co-operation with the University of Manitoba, Department of Medicine. That is allied with the Medical Research Council but it is really their program which we are assisting, so we really have no medical research. We supply isotopes and other things for the medical profession. This question is very timely as about two months ago we were looking at the radiation biology research within AECL, in regard to requirements by Whiteshell and Chalk River for new pieces of equipment and new buildings. The Board looked at this and started thinking of what might be going on, because in the NRC there is a new division of radiation biology, and also as to what may be going on in the National Health and Welfare Department. We felt they might well be leading to duplication, so we asked the Government if they thought it wise, to review the radio-biology field. Such a review has started just now. I understand that the Science Secretariat has either just formed or is forming an independent committee, outside the Government, to review radio-biology in all the Government laboratories—and I think university work, though I am not sure, but certainly in Government laboratories. We

know by this review what we can expect to find if we are overlapping in the government. We will be advised to either switch work within AECL or NRC or to make decisions so there will be no overlapping. On the physics side we stay with the atomic energy field and have a good collaboration with the NRC. I do not think there is any overlapping in that area, although there is bound to be a little with universities using our facilities. We are contracting with universities—I think this is well known—mainly in the use of our facilities, big reactors and big accelerators, which do not exist anywhere else. I think in that area there is no overlap. The radio biology is the one area that is certainly suspect and is being investigated.

The Chairman: I have a final question. On page 8 of Appendix 5, there is a chart showing part of your organization. I see two columns each under the name of the two vice-presidents, Dr. W. B. Lewis and Mr. L.R. Haywood. In one column I see biology, health, and physics, and in the other, applied physics. The first column shows chemistry, materials, and physics and the second column shows applied physics. I would like to know what collaboration and liaison is being carried out between these two groups.

Dr. Gray: There is really no overlap between health physics and applied physics. These are quite different fields, however, they do complement each other. The applied physicists in their work, which happens to be the main area where the ING study was done, require assistance from the health physicists with the health problems of the ING target area. This is done straight across the organization structure and you do not have to go to the top and back down again. Scientists, engineers and technicians talk back and forth this way. The applied physicist on the ING target requires assistance from the health physicist and gets it through committee arrangements or direct discussion.

The Chairman: Both groups report to Dr. Lewis?

Dr. Gray: No, one group reports to Dr. Lewis and the other group reports to Mr. Haywood. The dotted line between these two really ties the groups together, mainly through committees.

Dr. Lewis: It also means that all divisions under me are co-ordinated on the administration side, under Mr. Haywood, so that for administrative purposes they are linked together.

The Chairman: In terms of research projects, for instance, who initiates and who decides?

Dr. Lewis: I think we have grown very close together. I would have to take an individual case. We certainly are not separate.

The Chairman: Not separate, but both report to two different people.

Dr. Lewis: Sometimes we have committees to determine the program. It is a question of how much effort each—

The Chairman: Do committees really reach decisions?

Dr. Lewis: It depends on the chairman.

Dr. Gray: We have left one other line off this chart. Both groups come together and report to me.

The Chairman: Do you find that this administrative arrangement or method of reporting is working satisfactorily?

Dr. Gray: It is not the ideal arrangement. That is one of our problems, two heads located at one site. This is something we are living with and it is due to the people and our history. We do not recommend this and hope to change it within the next few months; however, it is working. We realize it would be better if the dotted line were a full line with just one head at Chalk River.

The Chairman: Are there any other questions?

Senator Cameron: Before you leave that point, Mr. Chairman, I was wondering what progress has been made in co-ordinatng the information retrieval facilities between the various research stations, universities and Government.

Dr. Gray: There is a lot of progress being made, but it is a very large subject.

Senator Cameron: I know it is.

Dr. Gray: It is a program that is attracting a lot of attention not only in Canada but throughout the world. There are major projects under way in EURATOM and International Atomic Energy Agency, and I am thinking only of the nuclear field. In Canada I think we have the main nuclear library at Chalk River, and it is closely co-ordinated with NRC, who have the main science library.

But the speed with which information is being generated now is building up to a tremendous volume. So scientists using the old way of retrieving information simply cannot

keep up. We all recognize that we have to get this on some computer programmed basis. I think real progress is being made, but just how we are going to go is not yet clear in Canada.

I think we are going to follow the EURATOM procedure for a while, but whether the new program being developed by the International Atomic Energy Agency is one we eventually adopt we will only know with time. It is a problem. We are all aware of it. We think we can see the solutions, but this is going to cost a fair amount of money to everybody in the world.

Senator Cameron: It relates to the question the chairman asked: are we sure there is no duplication between different research bodies? This obviously would be one of the answers.

Some of us had a look at the rather fascinating information retrieval down at Omaha, Nebraska, in the Strategic Air Command, and that sort of thing. There has been a big establishment at Carnegie Tech in Pittsburgh, where they have had courses for people working in this field. I am wondering what we are doing, not just in relation to atomic energy but to the whole scientific field. That leads to a second question. There is so much information coming out—I think it is doubling every two or three years, is it not—that the volume itself is so great that no one person can have the time to go through it all. It would suggest the need of another skilled group who can abstract and condense material. Are we doing anything in that field, so far as you know?

Dr. Gray: Yes. There was a very good paper on this subject at the International Atomic Energy Agency's general conference in September. A man by the name of Woolston delivered that paper. He is the Director of Information Services of that agency, and it happens that he used to be in charge of our Information Services at Chalk River. In his paper he brings out all of these points, not only the generation of information but the requirement for a method of abstracting and a method of identifying. When you require some information you have to use certain coded words that mean certain things and, if you push those into a machine, out comes the abstract of all the information you want. It may be 10; it may 200. Then they have methods of producing a number of pages on a small card. I think it is 12 pages. The little card is called a microfiche. Then you either use a reader to read it or you have it printed.

A lot of work is being done on these two points: how do you handle all that information and how do you identify it? This requires people who do nothing but identify the material so that you can withdraw it from storage when you want it.

Senator Cameron: Can we get a copy of that paper? Is it available?

Dr. Gray: Yes. It is a very good paper.

Senator Cameron: Yes, I can see that it would be.

The Chairman: Senator Lang, you wanted to ask a question yesterday about ING.

Senator Lang: Mr. Chairman, all I know about ING is what I read in the newspapers. I find it rather difficult to put the story together. I thought if our witnesses were able to give us the background and the origin of the concept and the inception of it, and then the factors or decision making process that was involved in its cancellation, it would be of interest to the committee. Perhaps a general idea of what ING is would be of some help to the committee; at least it would help me, Mr. Chairman.

Dr. Gray: Mr. Chairman, I think if I try to explain what ING is, it might be better than having Dr. Lewis do so, because he might lose you. ING started five or six years ago. The project came forward as a result of a request by the Board of Directors of AECL, to Dr. Lewis and the senior scientists, as to what major program we should be into 10 years from now. Should we be in fusion, in hydrodynamics, fast reactors? There was a long list of things, and at the same time a group of physicists at Chalk River had been working on the ING. I do not think they called it that at the time, but it was a method of generating neutrons by electricity—electric generation of neutrons. The staff at Chalk River and within AECL reviewed all of these things and this one came to the top so far as the scientists were concerned.

It was eventually approved as the right thing by the Board of Directors of AECL. It was the right thing for us to investigate for this program 10 years hence.

What the project involves, really, is our interest in neutrons because that is what our big reactors produce. We need neutrons in order to use them either to split uranium to make power or to irradiate materials in materials investigations, or for other purposes such as producing isotopes. The idea that was

brought forward was that if you could get high energy particles and impinge them on a target—and the target in the present case is a lead bismuth target—by a process known as spallation, you would cause more neutrons to be produced. It is a different process of producing neutrons. In fission you get neutrons being released. That is one way, but this other way is a different way and it is called spallation. You get energetic particles hitting the target and producing very high intensity neutron flux. It is higher than any known reactor. The objective was to produce neutrons for research, for isotope production and, in the very long term, as a method of producing more energy. That is, we could foresee that the energy that would be put into this machine would be less than the output of neutrons from it. If you took the neutrons that came out of it and then used them to produce energy, you might produce more energy in that way than you had put into the machine. So it is an electric way of producing neutrons. It is like a breeder reactor as, in theory, you could produce more energy from the machine than you are required to put in it. Of course, we never got to that stage.

Before we go into the process, perhaps Dr. Lewis would put that in more scientific terms. I have probably missed a few points. Would you like to describe the machine a little better or how it got started, Dr. Lewis?

Dr. Lewis: There is perhaps only one other thing to say, and that is that the machine itself came from the physicists who had been using the NRU reactor. We managed to separate out beams of neutrons and work with them to study the very small changes of energy which represent the motions of atoms in solids and liquids. So this had developed as a major tool for discovering the atomic processes going on inside ordinary solids and liquids due to temperature, magnetic changes and so on.

The other countries, with United States in the lead, France and Germany having a combined effort and the United Kingdom still talking about it, have gone to high flux reactors to get still higher fluxes than the NRU reactor. But this Intense Neutron Generator was suggested as being able to go one step beyond these fast neutron reactors in intensity for those purposes. Then, of course, all these other things were also there in the picture: the use of it as an electrical breeder, the production of isotopes and so on.

Senator Aird: Dr. Lewis, would you just amplify it one step beyond that?

Dr. Lewis: We do this rather in powers of 10. In the NRU reactor, we have about 10 to the 14th neutrons per square centimetre per second. In the high flux reactor it is a few times 10 to the 15th, and in ING it is 10 to the 16th. If you ask the materials people they will say they want 10 to the 18th and they are looking for higher factors. ING is only the next step above the high flux reactors.

Senator Aird: The point of my question is, was ING a bigger thing than is going on in the United Kingdom or the United States or is it, or was it, a different thing?

Dr. Lewis: Mainly different. The size is comparable, but one thing we haven't mentioned at all so far, and it is very important, is that ING because it covers so many things would also produce mesons, and these are unstable particles that do not exist ordinarily in nature. People have talked about building factories for mesons. One factory is being built at Los Alamos in the United States. This is under construction at the moment. If we compare ING with Los Alamos meson facilities, it would cost three times as much, but would have 60 times the power.

Senator Grosart: Is that MTA?

Dr. Lewis: No, MTA is dead. That was stopped in 1953 because at that time accelerators were not so well developed as they are now. But one would say that ING and MTA are very similar.

Senator Grosart: Did ING arise out of work the Americans have done on MTA?

Dr. Lewis: If we look back at history, one cannot say that. It was all secret in the United States, and they didn't tell us about it. We came on it independently at the same time in 1952.

Senator Grosart: It was declassified, I think, sometime in 1960.

Dr. Lewis: Yes, so far as I know it was declassified in 1960.

Senator Grosart: So they had been working on it from the early fifties?

Dr. Lewis: That's right.

Senator Grosart: But your decision to work on ING was as a result of independent research so far as research can be independent in the international scientific community.

Dr. Lewis: ING was brought down off the shelf when accelerators made an advance in

1963 which was after the information on MTA had been declassified. At that time we knew both those sources, but the recognition that we could do something practical had those two roots, and another line in the improvement of accelerators.

Senator Grosart: The reason I ask these questions is that I hope to get some clarification today of the very diametrically opposed opinions about ING that we have had. Obviously this is an area where politicians should fear to tread, but in the general area of science policy we are required to tread at the moment. I don't profess any knowledge of ING, but there is, as Senator Lang suggested, some information about the decision making process that went into the first decision to go ahead with ING and the decision when the Government decided to abandon it. It seems to me that this is an excellent case history of how science policy should not be made. My understanding, and I ask to be corrected if I am wrong, is that as far as public information is concerned, ING was supported by government for a couple of years to the extent of about $3 million. The matter was referred to the Science Council, and the Science Council, after very exhaustive study, recommended that ING be proceeded with along the lines suggested by AECL. It seems to me that the next step in the decision making was a letter to the paper by Dr. Graydon, Associate Head of Engineering at the University of Toronto, who said "This is a prestigious will-o'-the-wisp." This, despite the fact the Science Council had described it as "an original, well-conceived idea, which dares to push the frontiers of technology." In fact, I would like to read this into the record. This is from Report No. 2 of the Science Council:

> The Council concludes that the essential idea of generating neutrons by spallation is well-conceived and the unique prototype design around a proton linear accelerator appears feasible. (p. 4)
>
> The facility would be unique enough and scientifically important enough to have significant status in the international community . . . (p. 5)
>
> The Science Council recommends that AECL be commended for their foresight, imagination, and diligence in preparing a thoroughly documented proposal of broad scope . . . (p. 7) . . .
>
> The Committee has found the Proposal, to the best of its judgment, well-conceived and imaginative. (p. xi)
>
> We believe that the ING project is sufficiently unusual, daring, and even spectacular, that it can excite the public imagination and the national pride. (p. 62)

And so on. There is much more in the same line. So, we have a Dean of Engineering saying it is a prestigious will-o'-the-wisp, and we have a letter to the paper by a group of deans of engineering saying this is a terrible thing and that "all this money should go into universities and industry. This is a terrible device to put money into the government sector of research." Then we have some associate deans writing to the paper to say "We want to be disassociated from the other disassociated deans." Then we hear an announcement from the Prime Minister in Calgary—and personally I was expecting to hear that he was going to do something about the rain and the wheat—but the announcement was that they had instructed AECL to abandon ING. The point I make is this: Is this Government science policy making? Is this how policy is made today? If so, I think we have a job to do in this committee.

I would ask Dr. Gray if this is a fair summary of the situation. This is what we, the public, have. As far as I can find out there has been some work done on it.

Senator MacKenzie: Before answering that, may I ask what was the estimated cost of the proposal, roughly?

Dr. Gray: At first it would have cost something like $125 million, that is what we estimated the total initial capital cost would be. I think the total cost was $155 million, which is probably the sum mentioned in the Science Council report.

Senator Grosart: I think they allowed for a 25 per cent escalation.

Dr. Gray: It was really a $25-million-a-year project during construction and operation.

Senator MacKenzie: I think this is relevant to what happened.

Dr. Gray: It was a large major research facility for Canada, one of the largest. I think Senator Grosart's summary is quite good, but I don't think it is exhaustive.

Senator Grosart: I don't suggest it is, but what I would like to get is something more exhaustive to find out how this kind of decision making is done and what are the components. I am not criticizing the decision. I don't know enough to know whether the decision was good or bad, but as a layman I am

astonished that something that has this kind of endorsement from the council that was given the job of advising the Government on science policy should be treated in this way. This is not from a Dean of Engineering or someone like the gentleman I was quoting yesterday. This is from the body set up to advise the Government—and recently set up—and here is its first big piece of advice, and this is the result.

Dr. Gray: We recommended that the project be proceeded with. We made our recommendations to the Government, and the Government reached a decision. As far as I am aware, there was no criticism that the project was not a good, well-founded project, and, as far as I am aware, this opinion was never reversed as far as the Government was concerned. The decision to not go ahead was reached, as far as I am aware, entirely due to availability of funds. They were aware of the opposition of the Deans of Science and a few of the Deans of Engineering in a few universities and a few individuals, but there was a preponderance of support relative to the opposition. But, as far as we know, the decision was made on the availability of funds in the research sector at this time in the Government.

The Chairman: How much was spent on the project?

Dr. Gray: About \$4½ million from 1963 on through to now, and we have had a number of people assigned from industry and universities working on this. Some have already gone back to their companies and the rest will all be back before the end of this fiscal year. We have cancelled a lot of contracts and are winding up the ING project.

We have just had an initial report as to what we think we should do with the program, and there are some areas that certainly appear worth carrying on under our normal budget level for this group of applied physicists.

Senator MacKenzie: Will ING be out of date by the time you have the funds available to get round to it again—or is that an impossible question to answer?

Dr. Gray: I think that if it were a five-year delay we probably would not want to build it. Perhaps Dr. Lewis could speak to this.

Dr. Lewis: The world of accelerators is changing quite rapidly. When the initial ING proposal was put forward, we called the accelerator that seemed then to be the best the separated orbit cyclotron. But the developments at Los Alamos regarding their meson factory was so large that this made us change our reference design over to the linear accelerator.

There are further studies in the world on the linear accelerator, particularly at Stanford University on super-conducting linear accelerators. Some people think that will take over from the Los Alamos type.

There is, however, another far-reaching prospect in accelerators that was announced by Russia in September, 1967. This is not a new idea, but it was new information that they were, in fact, building an accelerator by this means, and this has been taken up by a group at Berkeley and Livermore in California. We have been following this very closely, and participating to some extent. This has some way to go, but if it is successful it should do very much better.

Let me say that when we are thinking of using these neutrons in the power cycle, we would certainly need a very much better accelerator than the one we were proposing to build for ING. It may very well be that this electron ring accelerator may be the ultimate, but this is a tremendously interesting stage of the work. One cannot yet say whether it will come through or not, but within a year we expect to know a lot more.

Senator MacKenzie: If I could comment on Senator Grosart's question on policy-making: I do not profess to know as much about politics as he obviously does, but on the basis of my own experience on the fringes of this area, if a government is confronted with a difference of opinion among alleged experts and it does not want to spend money, or is interested in economy, this is the best way of ensuring that a thing will not be carried out. Disagreement among the alleged experts gives any government one of the best excuses possible for dropping something, if they want to economize and save money and are not too enthusiastic about it anyway.

The Chairman: But you started this work in 1963?

Dr. Lewis: Yes.

The Chairman: Did you have an estimate of the total project at that time?

Dr. Lewis: In 1965 we invited the universities to participate in a symposium, and at that symposium I said that the problem we have in this study is to see if we can build

this thing for less than $100 million. I was putting this forward as a challenge. We thought it was very doubtful that we would be able to and, in fact, I would say that there has been no change in the overall assessment of the magnitude of the project.

Dr. Gray: It was not until 1966 or 1967 that we started to look at the sizes of the numbers.

Senator Grosart: I do not want to be misunderstood. I am not in any way concerned with, as may have been suggested, the political aspects of this. I am trying to put the Science Council in its proper context in Government policy-making. Senator MacKenzie suggested I am talking about two different groups of experts. That is not my point at all.

What I am saying is that we have the Science Council which has recommended this. What is going to happen in the future? What is the use of the Science Council? Perhaps this is something we can ask them when they come before us, but if the Science Council is to be overruled on the basis of letters to the papers, as far as we know, this is the essence of my point here.

The Chairman: I do not believe the final decision was taken just because letters were sent to newspapers.

Senator Grosart: That is what we are here to find out, Mr. Chairman, and our friends from AECL are the people immediately concerned, and I wonder if they know, but they say the decision was made only on the basis of fund availability.

There were many other projects that were continued concerning which all the experts were not unanimous. This one was picked off after an expenditure of some $612 million by AECL on this whole project.

The Chairman: Not on this project alone.

Senator Grosart: No, this is my point—and I am coming to it now. The commentator says:

> One of the possible uses of ING was to allow AECL to keep the doors open to breeder reactors.

If this is so, it has to be put against the whole $612 million, because we were talking yesterday about the possible danger of ECL having all its eggs in one basket, the natural uranium heavy water reactor. Was this one of the main reasons for getting into ING, to keep the doors open in this breeder reactor area?

Dr. Lewis: Yes.

The Chairman: Was it not a very indirect route?

Dr. Lewis: What we said was—and I am afraid I cannot remember exactly the document it is in, but it was addressed to our board of directors—that we felt it was time we broadened our base. This was in answer to their request for information as to what we would be doing in ten years' time. We know we have never been as broadly based as the United Kingdom or the USAEC, and we felt it was time to broaden our base, and that this was a field in which we could broaden our base most effectively. Always in front of us was the feeling that eventually this would be taking part in the overall competition with the breeders, but at the same time, it would give us other lines of technology that might be blended with breeders. We envisaged the possibility of having small fast reactors associated with large heavy water reactors, but these are just technical ideas.

The Chairman: In other words, in your mind it was a kind of all-purpose exercise to broaden the basis of research?

Dr. Lewis: Yes.

Dr. Gray: With respect to Senator MacKenzie's point I would agree that if you have opposition to anything then it is much easier to turn it down. I think that this is a fact of life, and in a project of this size you are going to have opposition to it from somewhere—from people who have not been closely associated with it. We have tried to involve many people in this. We certainly did not try to slip this in without the public knowing about it. We had open forums at which we discussed it, and separately with presidents of universities and deans of science. So, it was very much in the public eye. I notice that Dr. Solandt said that if we had really got the scientific community behind us, the Government could not have turned it down, but I think it is virtually impossible to get 100 per cent support for anything.

Senator Grosart: I agree.

The Chairman: This sounds like what was said of the generals of another period. If they all agreed, they could take over.

Senator Robichaud: I do not know whether Senator Grosart meant what he said when he said that the Science Council was overruled by the Government. It is true that the Science Council recommended that the project be proceeded with, and the Government decided not to proceed with it, but I do not know that we

can take the interpretation that the Science Council's recommendation was overruled. I think the facts are as we were told, that the Government decided, probably because of financial conditions and other considerations, not to proceed with ING, but I do not think it is correct to say that the Science Council was overruled. I do not think that is a correct interpretation of the decision that was made.

Senator Grosart: Well, it is only a matter of semantics. If "overruled" is too strong a word, I will not insist on it. The point I am making is that the function of that Council is to try to bring before the lay political decision-makers the consensus of scientific opinion in the country. Whether you say the Government ignored it, or paid no attention to it, or discussed it but did not follow it, I do not care. But, I do not like the suggestion that it is necessary for some people to rise to the defence of the Government in this matter, because I am not criticizing the Government.

Senator Robichaud: It is just that word "overruled" that I do not like.

Senator Grosart: I do not care what the Government does. If anybody wants me to put a little political balance into the discussion I will say I will not defend the Arrow decision here.

Senator MacKenzie: Mr. Chairman, you know that I am not a scientist, but in respect of this I do know that one of the reasons given by the groups which were unhappy about ING was that it would absorb too much of the money available for this kind of work. They felt that if this same amount, or even a lesser amount, of money were available for a number of other small projects they would be happy. They believed this was going to eat up all the money available for work in this field, and this was, in part, the reason for the disagreement and opposition to it.

Now, because I point this out it should not be suggested that I go along with that view. I am one of those people who believe that it is not in the nature of human beings to agree among themselves one hundred per cent, and this is particularly true of academics and scientists. But, if you get as close to a majority as you can, or a good majority, then your chances of getting action are better than if there is a desire among different groups to do different things.

The Chairman: To come back to Senator Grosart's point, my view would be that the Science Council was not overruled, but that the Science Council gave scientific advice to the Government and, in so far as I can interpret the following events, the federal Government reached a financial decision. It did not reach a scientific decision.

Senator Grosart: Somebody made the comment—and I have forgotten who it was—that we are back to where we started. The Treasury Board is making science decisions.

Senator Lang: Mr. Chairman, I think what I was going to ask for comment on has been partially answered by what Senator MacKenzie said in his remarks. I am wondering if really at the root of these problems that we had in connection with ING and the telescope is basically a conflict between different interests for the amount of money that the Government has available for spending in the scientific field. Among experts I know that as an opinion becomes more refined differences that occur are often not fundamental to the merits of the issue, but because of more extraneous considerations that unconsciously come into the picture. I am surmising that behind this lack of policy or lack of direction we are really witnessing a contest for support in the field of science between competing interests. I would like to know whether that observation has merit, Dr. Gray.

Dr. Gray: You are asking whether the idea of competing for a small bit has merit, or whether...

Senator Lang: No, whether my concept of this problem has merit.

Dr. Gray: I think it has. There is no doubt that the availability of funds is less now than it was a couple of years ago—that is, relatively. I do not think there is any doubt but that the availability of funds would increase if the idea that the Science Council had, and that many of us had, that R and D should be a little higher percentage of the GNP, were adopted. This we are not doing in Canada at this stage. At least, I see no evidence of a relative increase in expenditure on R and D this year, or next year. If we were trying to get up to 2 per cent of the GNP then I think there would be ample funds available for all of these projects.

Senator Lang: But, I am suggesting that if there had been ample funds for university research—all that the universities could absorb—and ample funds for a project such as ING, then the critiques of the ING pro-

gram, and the criticism that came from the universities, would not have arisen.

Mr. Gray: I think that this is largely correct.

The Chairman: Surely, this is analogous to a cabinet meeting without the Minister of Finance. It can very easily agree on all of the projects coming from the various departments.

Senator Lang: I think that this is going to reappear in our hearings, Mr. Chairman. This committee is going to have to come forward with some sort of recommendation because this seems to lie in a very fundamental area of our inquiry.

Senator Aird: Accepting Dr. Gray's answer that in effect it was a limited budget that stopped the ING project, I would like to go back a little back to Senator Grosart's remarks about the decision-making process, and ask you if there is a possibility that because of comparable United States activity in a comparable field there is a security problem involved here—that is, as it relates between Canada and the United States. Do you think the U.S. activities in this field had a bearing on Canada's decision to continue?

Dr. Gray: I am not aware of any. As far as the scientific community in the United States is concerned, the United States Atomic Commission were wholeheartedly behind this program in Canada; they thought it was a good program and complemented the work at Los Alamos.

The Chairman: Complemented and not competed with?

Dr. Gray: This is a different line. You might like to hear Dr. Lewis on this. I am not aware of any feeling of competition. I think they would have been very pleased to see us with a neutron flux of ten to the sixteenth or ten to the seventeenth. Were you aware of any, Dr. Lewis?

Dr. Lewis: No.

The Chairman: I understood you to say a moment ago that the MTA was, originally at least, a very similar project. I have been told that as a result of the work they have done on that project in the United States a lot of patents were taken out on that project. Would the fact that these patents were taken out in the United States have prevented you from developing your own project to the end?

Dr. Lewis: No, we would not have been worried.

The Chairman: Why?

Dr. Lewis: We have very good relations with the USAEC and I am quite certain they would have made over patents that were really valuable to this program.

Dr. Gray: I do not think there is any doubt the patents would have been available to us if there was any infringement of patents, or appeared to be any infringement of patents.

Senator Thompson: If you had been aware that there was going to be a budget cut for all your operations to the extent that it affected ING, would you have suggested then that there would have been a cut in some other research?

Dr. Gray: No. The board had reached the decision that the other program had to go ahead, that next year there had to be something like $5 million for ING. In fact, when we put the budget in for next year—which has not been settled yet—there was an item for ING for $5 million as a support item, and if ING did not get approved we would not have taken $5 million or something less out of the regular program. Our program is so tight on the power reactor side, and other science activities at Chalk River and Whiteshell, that we simply could not make any adjustment. We have been making adjustments in the last few years to support ING. The first three or four years it got support entirely under our normal budget, and in the last couple of years we got some specific support for ING. The answer is that we would not adjust the rest of our program to support it; it is too big.

Senator Grosart: Is this a comparable development to the meson factory development?

Dr. Lewis: As far accelerators go, the intense neutron generator was 60 times the power of that.

Senator Grosart: Dr. Rosen of Los Alamos was very enthusiastic about the future of this project. Perhaps I might quote him from the AEC hearings in 1968. I think it is rather interesting in this context. He briefly summarized the scientific motivation, and talking of the meson factory he said:

> It is becoming ever more apparent that the meson factory offers a means of achieving the next stage in our understanding of the structure of nuclei and of the forces by which that structure is governed.

I omit a paragraph which only reinforces that.

> Our hopes for the utilization of a meson factory in practical applications have also been reinforced during the past two years.

Then he refers to the weapons aspect.

> The need in the weapons program for very high intensity neutron sources to mock up the neutron environment produced by a nuclear explosion has not diminished.

I presume it is in that very large context of scientific horizons that we are anxious to spend this additional money on ING. Is that correct?

Dr. Lewis: Yes. We have some very close relations with Dr. Rosen and his group at Los Alamos. One of the Chalk River staff is attached there at the present time and reporting regularly to us. We believe we have helped them; we know they have helped us.

Senator Grosart: We are really dealing with science policy decisions in terms of priorities, and the Science Council in its report indicates certain priorities. The point I am making is that from all the evidence I have been able to gather this seems to have been a priority that should not have been moved down the list as a result of a decision-making process, which appears to me to have been superfluous, as I have indicated. It is not good enough just to say "We did not have the money" without giving a reason, without saying, "This is not necessary, we do not need to expand our science horizons. We have decided not to go from the 1.3 per cent of G.N.P. to anywhere close to 2 per cent", in spite of the fact that practically all the things we have heard here indicate that if we do not move up our total expenditure on R and D from 1.3 per cent to 2 per cent of G.N.P., as one prominent scientist said the other day, we are in danger of becoming an undeveloped country in 20 years. This is the point I am making, because here we are dealing with Government function and science policy making. I think that is why it is an interesting case history.

The Chairman: Would there not be another similar or parallel problem? For instance, we have been told that that in Belgium at this moment they are devoting a lot of energy, consultation and thought to preparing a special science budget which is different from the rest of the budget. We do not have that here. If we had some kind of special budget for science and research, I wonder if these decisions would be taken in a better environment, in a better overall framework? If you do not want to comment on this, Dr. Gray, I will ask Mr. Golden to comment.

David A. Golden, Director, Atomic Energy of Canada Limited: Sure, I will comment. I do not think you will end up with any different answer to the one we talked about earlier, if the demands are going to greater than the available resources. I might add that within the board of directors of AECL, when we talked about ING there were some real hesitations about ING if it meant cutting back on R and D in industry or in the universities. That is not the way we conceived of ING. We conceived of ING as an increment to government support to research and development, not a substitution therefor. In this world everybody wears more than one hat and there were many of us with interests in the universities and elsewhere who were most anxious that ING, if proceeded with—and we were in favour of it—should be proceeded with as incremental thereto and not in substitution for something else.

Senator Leonard: Therefore if the funds were not available ING did not have priority to take away from anything else?

Mr. Golden: As Dr. Gray said, we have a primary responsibility on the board of AECL to insure that this enormous program, on which Ontario Hydro and others have embarked, gets proper government support, and we could not recommend that it be cut back to support ING.

Senator Aird: We appreciate that this decision has some obvious disappointments for AECL. Does it not have some merit in that it leaves you with a flexibility of choice? You have just discussed the flexibility of choice that you had within your own board of directors.

On the decision to continue, I recall Professor Arthur Porter being before this committee and I believe he said that the interaction between the scientific communities is continually accelerating. This goes back to my previous question relating to the United States. This decision to discontinue, this hiatus, leaves you with a flexibility of choice, leaving you with a decision on improving on ING, even so many years from now. Is there any merit in that?

Mr. Golden: Let us be perfectly clear, there was no AECL decision on ING.

Dr. Gray: I doubt very much if there is any merit. We now have five years to make a choice and a decision, which then will be cancelled; and then five years to make another choice and then it will be cancelled. We know that everything we do is outdated by the time it is done. The reactors we built are not in that position, because they use a low cost fuel, but the Douglas Point Reactor has been improved upon and in turn the Pickering reactor. I am sure that if ING were built, we would wish we had a different type of accelerator, and if we wait to have a different type of accelerator developed we would have a different type of ING, but if we continue waiting for the ultimate development we have nothing. So there is this freedom of choice, so long as you do nothing.

The Chairman: So long as you build nothing.

Senator Grosart: If you cut your wife's allowance it is a good thing because it gives her a little more flexibility in the shopping basket.

Senator Cameron: There is something fairly fundamental in relation to the scientific world. This decision has obviously been built on the basis of economic priorities. Can you tell us, thinking in terms of the fantastic expansion of scientific knowledge and development, what is the minimum lead time that you need to have, to have some assurance in planning these projects? Is it ten years?

Dr. Gray: With a project like ING, certainly ten years from the time you start it to when you have it in operation. Any new reactor is ten years—it takes about five years to build it.

Senator Cameron: If you start doing this, it would be pretty bad, even recognizing the economic factor of life, after you have planned your program, with a view to bringing it to fruition ten years ahead, if the Treasury Board, even for the best of reasons, says you cannot do it. We cannot move forward very fast in that way. Does it not suggest that one of the recommendations this committee might make is that there be something in the nature of a protection of a certain amount of lead time on certain projects? I do not know whether this could be worked out or not.

Dr. Gray: It would be certainly advantageous to us in our planning, We feel we have fairly good protection in our basic program but, as was mentioned earlier, if there were some way of knowing you were going to have a 10, 12 or 14 per cent increase, or even that we were going to keep up to the escalation with the normal program, and any new program, this would help. We put in five-year budgets, every year, but they are not approved, they are in for information.

Senator Cameron: If we do not do something like this, are we not going to find ourselves perhaps twenty years behind? This is the crux of the matter.

Dr. Gray: We know that everything has to get its fair share, but we do have to have this increase in Canada or we are going to be in trouble in a few years.

Senator Grosart: Would you say that this decision to postpone or cancel the ING project now substantially limits the opportunity for you to start working on an alternative to the heavy water reactor?

Dr. Gray: No; other than that it is disappointing. There was a group of people working on it; the type of people deeply involved become disappointed with such a decision. I do not know whether they can be put on a new reactor system. Many of them have given four or five years of their scientific life working hard on this and it has stopped at the time when they were coming to the point of seeing how to build it.

Senator Grosart: You will be able to keep these people with you, I understand?

Dr. Gray: We will keep our own people, but 25 per cent of those on the project were not AECL staff. A fairly large per cent of the work was under contract with industry, we will have to drop that. There will be a slowdown and then a pickup. These men are too good to keep down, they will come up with ideas and hope the next one will go ahead.

Senator Thompson: What are the limitations on a decision to go ahead and then another decision to stop? What effect has this? I can see a number of things in morale and also perhaps in loss of information. What would you count as the priorities of limitation, in the effect of the decision by the Government to curtail the program?

Dr. Gray: I think we could answer this suggestion much better in six months' time. We want to see what we can do and what we can salvage and see what project may be

profitable or what might be unjustified. There is enough to do, I do not think there will be much difficulty. There was certainly a change in morale in Chalk River when the project was cancelled. It did not come very suddenly as we had a pretty good idea it might be cancelled and kept people advised. But there is bound to be a drop in the morale, depending on the individual. If we can get enough funds to finish some part of it, perhaps the target area, where we are pumping around lead bismuth in a fancy way—if we can finish this work which is related to fast reactors in a year or two, this would keep some satisfied—but not forever, because they really want to see their results applied. Even though fundamentally they are scientists, they like to see their efforts built into something that is good for the country.

Mr. Golden: Perhaps another answer to Senator Thompson is the question the board of directors asked in 1963, as to what they were going to do in 1973; it is still unanswered. Perhaps that is the most important aspect of this decision.

Dr. Gray: It is a question of picking the next best thing. I remember that there was a case of the magneto hydro dynamics, as to whether we should go ahead with such work. The Board was reluctant to support that line. I think we will find an alternative solution.

Senator Thompson: From listening to you, it is not a case of a team which is disintegrating and all heading down to the United States, it is not a case of information which would be classified. We are getting information concerning new advances in this field from the United States and from some other countries. Just as a layman listening to the effect of this, it does not seem to me to be quite as devastating as I first thought.

The Chairman: If something else is developed.

Dr. Lewis: I should support what Mr. Golden has said, that we feel that we have got an extremely good line of heavy water power reactor that can go a very long way. I myself am quite seriously worried that this is not adequately supported to keep in the competition, that the target is moving, other people will be making advances and the competition becomes tougher. I certainly could not recommend taking people off the power reactor program to put them on ING, even though I feel that we are very narrow on the heavy water reactor. It is in our brief, this is our message—what prevents us from going forward is the limitation on funds.

The other aspect of this is that we do not individually take more money. It means that if there is more money, more people are involved in the program. We even do not have to keep it within AECL. The suggestion is in the brief, that we would expect this to grow, as we ourselves grew in the past from being a division of NRC to becoming Atomic Energy of Canada. We see this type of growth as being very natural. We certainly are mission oriented. We want to get these things into competition and keep them there and it is quite a problem at the present time facing the unnatural sequence—a slight increase, then a drop. Then it is very difficult.

The Chairman: Honourable senators, as there are no more questions, the committee will adjourn. Before we adjourn I would like, on behalf of the committee, to thank Dr. Gray and his colleagues for spending so much time with us and for giving us so much useful information. Thank you very much, gentlemen.

The committee adjourned.

APPENDIX "5"

Atomic Energy of Canada Limited

SUBMISSION

TO

THE SENATE OF CANADA

SPECIAL COMMITTEE ON SCIENCE POLICY

October 1968

CONTENTS

BRIEF HISTORICAL BACKGROUND

Although atomic energy studies in Canada can be traced back to the turn of the century, it was during the Second World War that the present programme had its beginning. In fact, although there were no celebrations or other observances to mark the occasion, the 25th anniversary of Canada's entry into the field occurred in 1968.

2. As is well known, the initial research effort was directed toward the production of material for atomic weapons and was cloaked in the utmost secrecy. The people of Canada were very surprised indeed when it was revealed, in August 1945, that "by far the largest organization ever created in this country to carry out a single research project" had been engaged in atomic research in a laboratory in Montreal and that construction of a pilot plant for the production of atomic materials was well advanced near Chalk River, Ontario.

3. With the war ended, the government of the day was faced with the decision whether the Chalk River project should be continued or be run down along with the rest of the war machine. The decision was made (and a very important one it was) that Canada should capitalize on its early start in atomic energy research. In 1946 the federal government passed the Atomic Energy Control Act providing for the control and supervision of the development of atomic energy for peaceful purposes.

4. A major milestone was reached the next year, when the NRX reactor was commissioned at Chalk River. NRX was an experiment, a departure into the unknown, and it proved to be an outstanding

success. For some years it was the world's most powerful research reactor and it is still giving valuable service. Ten years later came NRU, a reactor with ten times the initial power of NRX and with experimental facilities that enabled Canada to remain in the forefront in nuclear science and technology.

5. It will be recalled that it was the National Research Council that first directed the atomic energy programme in Canada. However, as Chalk River grew in size and as the commercial aspects of the programme became more apparent, it was realized that a separate, specialized organization was required. This led to the creation early in 1952 of the Crown company, Atomic Energy of Canada Limited.

6. Shortly afterward a division of Eldorado Mining and Refining Limited that had been formed to handle radium sales but which then was also marketing radioisotopes produced in the NRX reactor, was transferred to AECL. Just a year earlier this group had attracted worldwide attention for its part in the development of the first Cobalt-60 commercial therapy unit ever to be used in the treatment of cancer.

7. By force of circumstance more than anything else atomic energy work in Canada was confined, to begin with, to the use of heavy water as a moderator for nuclear chain reactions. This line of endeavour proved to be so successful and so promising that when the Canadian programme was continued on a national peacetime basis, concentration on the use of heavy water was natural.

8. Nuclear power was a challenging target for the scientists and engineers, but it was not for several years that sufficient confidence and experience were accumulated so that they could see that

the unequalled properties of heavy water would allow power reactors to be designed to operate efficiently on natural uranium fuel.

9. In 1954 a study was made of the application of nuclear power generating stations in Canada. This led to a decision to design and build a Nuclear Power Demonstration station of 20,000 kilowatts at Rolphton, Ontario, as a co-operative venture involving an industrial firm (Canadian General Electric Company), a provincial public utility (Ontario Hydro) and AECL. NPD's main purpose was to establish the feasibility of the Canadian design and to provide verification of the basic principles of the heavy water natural uranium system. Since starting up in 1962 it has convincingly achieved that objective.

10. Well before NPD was completed the concept had become sufficiently promising that the government of the day decided to commit a commercial-size plant of 200,000 kilowatts at Douglas Point, Ontario. In turn, Douglas Point was still in the early stages of construction when an agreement was reached whereby AECL was to furnish the nuclear design and other engineering services for a similar station in India.

11. In 1962 Ontario Hydro and AECL discussed the possibility of building a plant significantly larger than Douglas Point. The ultimate outcome was the decision by Ontario Hydro to build the Pickering nuclear power station, 20 miles from the heart of Toronto. The initial commitment was for two 540,000-kilowatt units; this has since been doubled to four units.

12. On the St. Lawrence River not far from Trois Rivieres, AECL is building, in co-operation with Hydro-Quebec, a nuclear power station with a designed capacity of 250,000 kilowatts. This is

a prototype of a new type of reactor. Like other Canadian stations, it will use heavy water as moderator and natural uranium as fuel, but for the coolant it will use boiling light water in place of pressurized heavy water.

13. To round out the family of Canadian heavy water power reactors, the Canadian General Electric Company is building a 137,000-kilowatt plant near Karachi for the Pakistan government.

14. So, all told, there are at present six nuclear power stations of Canadian design either in operation or under construction. Four are in Canada, one is in India, and one is in Pakistan. Their total designed capacity is in excess of 3 million kilowatts and they represent a total investment of more than $900 million. Designs for nuclear power units of 750,000-kilowatt size have been under way for over a year, and Ontario Hydro has announced that it may make a commitment for a new station with an output of 3 million kilowatts before the end of 1968.

15. Running parallel to the nuclear power programme has been an extensive research programme in both fundamental and applied fields of atomic energy. The scope of this programme and results in some selected fields are discussed in later sections of this submission.

16. Similarly, an extensive isotope research, development and application programme has flourished in AECL with the Commercial Products group carrying the main burden of programme selection and pursuit through to commercial sales, supported by work at the research establishments.

Appendix 1

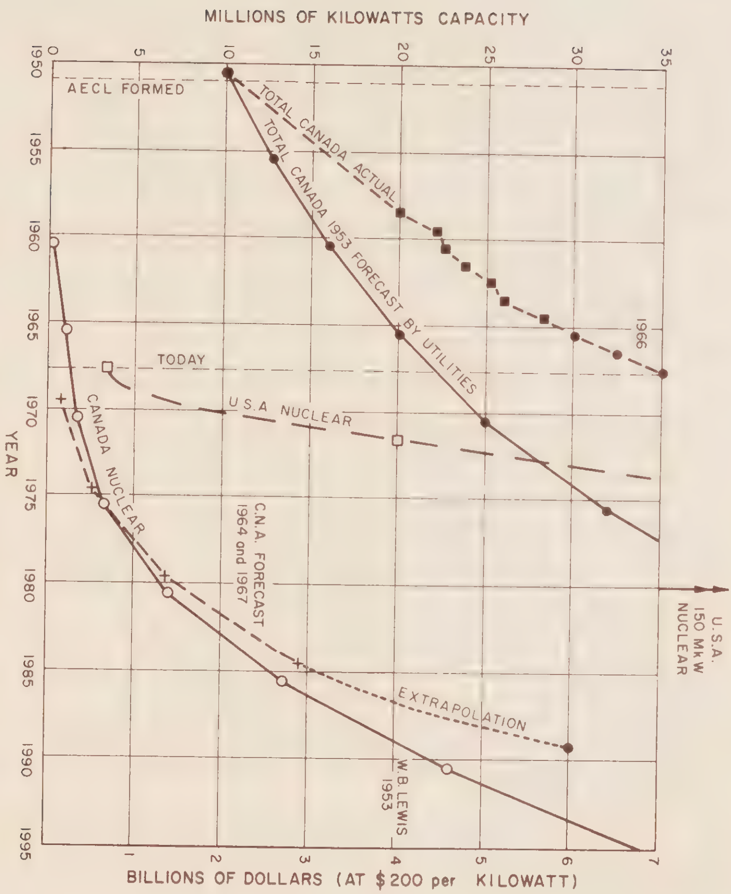

FIG. 1A. FORECASTS OF ELECTRIC POWER

BACKGROUND AND PROSPECT

Nuclear Power

The forecasts shown in Figure 1A suggest that over the next 20 years Canada's investment in nuclear power generating stations will rise to a total of about $4 to $5 billion and will be increasing then at a rate of at least $3 billion in five years. The more recent forecasts were made by a committee of the Canadian Nuclear Association in 1964 and confirmed in 1967. They are not substantially different from the earliest forecast made by W. B. Lewis in 1953. AECL was only formed in 1952 so it can be said that this prospect has been before us all the time and served as a gauge as well as motivation for nuclear power development.

2. The credibility of these forecasts is discussed at some length in the reports by their authors. Here it is sufficient to note that the scale of millions of kilowatts generating capacity in which the forecasts are first made may be checked by referring to other points plotted in Fig. 1A. One line shows the forecast derived from the utilities in 1953 for the total electric power in Canada which proved, as shown, to be much below the actual installation. Nuclear power for some time will be only a small fraction of the total generating capacity and even by 1988 nuclear power is less than one-quarter of the forecast total.

3. Further evidence of credibility may be seen from a comparison with the nuclear power capacity in the U. S. A. that already

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exists or is in early prospect. The three points shown correspond to the reported operating capacity of 2.8 million kilowatts at the end of March of this year, stations having a total of 20 million kilowatts capacity already under construction, and the forecast of 150 million kilowatts by 1980 suggested by the U.S. Atomic Energy Commission. The U.S.A. has been taken by surprise by the rapid rate of investment. Our forecasts are small by comparison but they are not insignificant.

4. The objective of research and development is to allow the power demand to rise and be met without involving too high a cost either in capital investment or for operation. The scale on the right of Fig. 1A corresponds to an investment allowance of $200 per kilowatt. Our current target is to reduce this for nuclear power to $160/kW and there is good prospect of achieving this if we press ahead and do not falter.

5. So far only Ontario and Quebec are committed to nuclear power stations but their entry and the general world prospect indicate that other provinces in time will also adopt nuclear power with benefit.

6. The main features of the heavy water reactor system pioneered by AECL are that it consumes relatively little fuel, the fuel can be natural uranium and the fuel fabrication cost is low. Going beyond these low fuelling costs, a useful credit will come from the plutonium value in the spent fuels. Moreover, the fuelling system is flexible and can be changed to meet any changes in the market such as a rise in the price of uranium or a fall in the price of plutonium. The flexibility allows the introduction of thorium as a component of the fuel and may involve recycling of the fissile materials. Canada is not yet equipped with spent fuel processing plants or a uranium enrich-

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ment plant; such additions should come at such time as the market justifies them. For the present, natural uranium serves as fuel and there is a good prospect of selling the spent fuel because of the value of its plutonium content.

7. The sale of power is a component of the Gross National Product. If the generator of power receives 4 mills (0.4 cents) per kilowatt hour for a 7,000-hour year, the revenue is $28/kWyear. With 20 million kilowatts of nuclear capacity in prospect for 20 years from now, the total revenue then becomes $560 million a year.

8. All the forecasts in Fig. 1A are based on a normal extrapolation of power demand common to many industrial countries, but a new prospect is rapidly opening up. As the cost of power falls it can be applied economically to new processes including the desalting of water, the production of phosphate and other fertilizers, and the winning of metals from their ores. One prospect is of large industrial complexes gathered around large generating stations. Such "agro-industrial" complexes could be situated almost anywhere in the world. The chief requirement is the ability to concentrate sufficient organized effort into the region. Such developments are envisaged as being of major assistance to the larger of the developing countries or to large areas. They can be seen as a logical extension to Canada's contribution to nuclear power development in India and Pakistan. If the gap between the developing and the more industrialized nations is to be closed, we must share the best that we know. We may also expect these new industrial complexes to be established in appropriate

<u>Appendix 2</u>

locations throughout Canada.

Isotopes

9. It is anticipated that a high percentage of radioisotopes in use 20 years from now will be in new applications. Consequently, it is not possible to make a reliable forecast of the scale of their use at that time.

10. Canada pioneered in the production of Cobalt-60 of high intensity and in the design of advanced equipment for use in beam therapy, thanks to the high neutron flux in the NRX reactor and the initiative of several Canadian scientists. Building from this, AECL-Commercial Products has been able to secure and retain large fractions of the North American and world market for Cobalt-60. This market has continuously expanded because of increasing use in therapy, and recently in large-scale industrial irradiators for sterilizing packaged medical supplies, and for producing desirable chemical and other changes in industrial products.

11. Although Cobalt-60 therapy is not capable of curing all cancer patients, it is estimated that in 1968 more than one million well-patient years will result from treatments performed on equipment made in Canada by AECL. Of these, about 100,000 will be in Canada. Aside from the value in the alleviation of suffering, these people can and do make a very real contribution to the Canadian economy.

12. Cobalt-60 is the essential base of most of the revenue of Commercial Products but it is foreseen that other isotopes that can be produced advantageously in the NRU reactor may open up new and larger markets.

13. The U.S. Atomic Energy Commission and the U.K. Atomic

Energy Authority support broadly based programmes to develop their national capabilities for the large-scale production and use of isotopes as sources of heat and radiation. The programmes cover applications to health, space missions, oceanography (including off-shore search for minerals), navigation aids, and aids to well-logging and mineral prospecting. The field is so diverse that it is possible to exploit the low cost of some spare neutrons in the CANDU reactors and the high intensity of neutrons in the NRU reactor to make selected isotopes and so gain a competitive edge in the markets that will be established.

14. Estimates of the total volume of annual business in several realistic forecasts from the U.S. put it in billions of dollars so there is room to expand if the opportunity can be seized. Much of the business acquired by Commercial Products comes from the associated equipment and services offered. It seems almost certain that similar innovation and comprehensive services will be the key to Canada's future position in this field.

15. The wide range of uses of many special isotopes on a small scale, particularly as "tracers", continues to create savings in many large-scale industries throughout the world. The benefits to industry are considerable but the revenue to the supplier of isotopes is small and supports little development. Probably for this reason, government support will be maintained and grow in an increasing number of countries. Data have been published for savings to industry in a number of countries, including the U.S. and U.K. Pro rata savings should be available to Canadian industry if adequate applied research and development is done. This would require a substantial increase over present AECL activities toward such applications.

Appendix 2

Fundamental Research in Nuclear Science

16. Not only through the use of isotopes but also in applications of nuclear radiations, neutron beams and special particles such as mesons, nuclear science is spreading through the chemical industry and the science of materials. Our output and contributions are developed in Appendices 13 and 14.

Reduction in Unit Cost of Energy

17. One world-wide development dominates all others in atomic energy. It has now been demonstrated that nuclear generation of thermal-electric energy is not only feasible and economical but that the more energy one requires the cheaper it becomes and that resources to produce this energy are virtually limitless.

18. Although our civilization depends on the use of ever-increasing quantities of energy, the basic philosophy has been that with time it will become more expensive and new supplies scarcer. It will take some years for national leaders to adjust to the new situation, but even now it is clear that:

(a) Current high rates of yearly increase in demand for electric power, rather than decreasing (as was previously expected) may even grow.

(b) Canada can well maintain her position as a favoured site for supplying large amounts of low-cost electric power. To hold this position, however, will involve some change in our present economy as an increasing number of nations gain the same position.

(c) To meet the international competition in atomic energy the necessary research and development may well involve some increase in our overall effort.

(d) If Canada continues successfully in atomic energy research and development, export of the resulting products will help to meet increasing world demands and also to offset the economic change mentioned in (b).

19. On the world scene nuclear power is finding its first economic application in highly industrialized regions, where the demand is sufficient to make the capital available and muster the large engineering construction effort. Moreover, chemical processes using power more intensively will progressively take over from others as the unit cost of power becomes lower. As mentioned in paragraph 8, it has been foreseen that power-consuming industrial complexes will grow around major nuclear power installations. Since nuclear power can be located almost anywhere in the world, it is seen that "agro-industrial" complexes that desalt water and make fertilizer as well as extracting metals from their ores chould become economically viable anywhere the effort can be mustered. The door to this future opens now that economic nuclear power stations of several million kilowatts capacity are being designed in Canada and elsewhere.

20. Looking at Canada's programme in detail, we now have the CANDU line of reactors developed and coming into industrial use as sources of low cost power. As this is a new and rapidly growing Canadian development, one would expect the federal government agency (AECL in this case) to provide research and development for some time, although our effort in this particular sector may start to diminish as design and operating problems become better understood and as industrial effort increases.

21. However, this picture is modified by two general areas for logical development of our existing reactors which will lead to advanced models. Improvements will result in lower unit energy costs and even small savings result in very large economic benefits due to the rapid rate of increase in nuclear-electric generating plant output. Also world competition, which is based on large-scale government research and development in an increasing number of countries or groups of countries, will demand falling costs.

22. The first area for development is capital cost reduction. The construction of generating units of still higher power, combined with more engineering experience, will have a major effect. Another major reduction would be achieved by raising the net efficiency of generating stations from about 30 to 40 per cent or more. This programme will require a large effort by AECL in materials (including radiation effects) and heat transfer research and in fuel and fuel channel development. Prospects for success are very good, for our pressure tube design of reactor lends itself to such an approach. The sums of money involved in such an increase in efficiency are large. For Canadian requirements alone for nuclear generating stations in the 10-year period commencing in 1982, the expenditure at $160/ekW (present dollar value) would be about $4 billion, and a 33 per cent increase in efficiency could be expected to save $300 million or more.

23. The second area for development is in improved fuel utilization. Although our fuel costs are the lowest, our competitors are carrying out plans for fast breeder reactors, hoping to overtake and pass us. AECL must therefore carry out a programme to exploit

fully all the advantages of the CANDU fuelling system, which is much more flexible than those in competing reactors.

This will entail:

(a) development of thorium as a fuel and its use in CANDU reactors to provide an alternative fuel and also reduce costs;

(b) planning for, development and possibly construction of a rather complex chemical processing plant for irradiated uranium fuel, together with schemes for sale of the resulting plutonium or its re-use in Canadian reactors, to obtain the maximum economic return;

(c) development of techniques for evaluating and implementing the optimum (lowest cost) fuelling programme for a reactor depending on costs of uranium, thorium, plutonium and uranium-235, and prices obtainable for plutonium and uranium-233.

24. In brief, development of our existing reactor lines will lead to advanced reactors of high power with much lower unit capital and energy costs than realized today. However, we have also stated that considering the world resources of uranium and thorium there is no longer a barrier to the ever increasing use of energy. Moreover it is expected that, in the long run, nuclear reactions other than fission, in particular the electrical generation of neutrons, will contribute to lowering the cost of energy production and limit world demand to the more readily available resources of uranium and thorium.

25. Seeking to produce neutrons in higher intensity than available from any existing or projected nuclear reactors led to the proposal of the device that was called the Intense Neutron Generator

(ING). This was envisaged as a machine for the electrical generation of neutrons, for ultimate incorporation in economic energy production. As well, selected isotopes produced by high intensity neutrons might be made in an ING facility to compete with production in very high flux reactors.

Appendix 2

STATUTORY FUNCTIONS AND POWERS

Atomic Energy of Canada Limited was incorporated in February 1952 under Part I of The Companies Act, 1934 (now The Canada Corporations Act) with all the rights and powers given by this Act and for the following purposes and objects:

> "To exercise and perform on behalf of the Minister, as defined in the Atomic Energy Control Act, such of the powers conferred on the said Minister by subsection (1) of section 10 of the said Act as the said Minister may from time to time direct."

Subsection (1) of section 10 of the Atomic Energy Control Act reads as follows:

> "10. (1) The Minister may,
>
> (a) undertake or cause to be undertaken researches and investigations with respect to atomic energy;
>
> (b) with the approval of the Governor in Council, utilize, cause to be utilized and prepare for the utilization of atomic energy;
>
> (c) with the approval of the Governor in Council, acquire or cause to be acquired by purchase, lease, requisition or expropriation, prescribed substances and any mines, deposits or claims or prescribed substances and patent rights relating to atomic energy and any works or property for production or preparation for production of, or for research or investigation with respect to, atomic energy; and

Appendix 3

(d) with the approval of the Governor in Council, license or otherwise make available or sell or otherwise dispose of discoveries, inventions and improvements in processes, apparatus or machines, and patent rights acquired under this Act and collect royalties and fees thereon and payments therefor."

2. The member of the Privy Council designated by the Governor in Council as the Minister for the purposes of the Atomic Energy Control Act is the Minister of Energy, Mines and Resources, the Honourable J. J. Greene.

3. AECL functions in much the same way as any other company except that shares (excluding the qualifying shares of the Directors) are held by a Minister of the Crown in trust for Her Majesty, and that it may only act as an Agent of the Crown.

Appendix 3

ROLE AND OBJECTIVES

AECL is the federal government agency primarily responsible for research into atomic energy and its development for peaceful purposes. While it has broad responsibilities, these are not as extensive as those of national atomic energy organizations in several other countries. AECL is not involved in the mining and refining of uranium, nor has it any regulatory functions such as the issuance of licences and permits. These responsibilities are assigned to separate federal agencies--Eldorado Nuclear Limited and the Atomic Energy Control Board. Under Canadian conditions it seems most appropriate to have separate federal organizations carry out these different functions rather than to have a single national organization responsible for all phases of atomic energy.

2. AECL does not have significant programmes of R&D in a number of atomic energy areas, such as fusion, isotope separation, energy storage and thermionics, due mainly to limited resources and the policy of carefully selecting lines of endeavour that appear to be most pertinent to Canadian needs.

3. Most of AECL's effort is devoted to research and development related to improved and advanced nuclear power stations. In the Commercial Products group, the main endeavour is the development of commercial applications for radioactive isotopes and other sources of radiation.

In the performance of its role, AECL -

(a) operates laboratories for fundamental and applied research and engineering development;

(b) designs and builds nuclear power stations, in co-operation with industry and utilities, and offers to supply nuclear power stations in the international market;

(c) provides nuclear consulting services as required;

(d) enters into research and development contracts with industry and the universities in the field of nuclear energy;

(e) makes available its special facilities and expertise to

(i) assist industry and utilities in putting nuclear energy to practical use, and

(ii) assist the universities in nuclear studies;

(f) produces and markets radioactive isotopes for use in medicine, industry, agriculture and research;

(g) designs, manufactures and markets equipment for radioisotope use.

4. Fundamental research has always been regarded as an essential part of AECL's role. Fundamental research does not range far and wide, but is selected mainly to exploit special equipment, such as research reactors and ion accelerators, and fields of work entailing ready access to radioactive materials and related to nuclear power development. AECL has found there is much to be gained from employing basic scientists at a major centre that is engaged primarily in applied R&D. The close association of fundamental and applied scientists promotes the interchange of ideas and expertise and increases the probability of new-found knowledge being brought to the attention of those in applied fields.

5. In the period immediately after the Second World War the

Chalk River Nuclear Laboratories were essentially a fundamental research establishment and at that time there was no firm prospect of nuclear power. Uncontrolled fission in the form of a nuclear weapon had been established, but it was not known whether it would be possible to control fission to utilize the large energy release in a practical way that would be economically attractive. It was not until the early 1950s that the Chalk River scientists were able to foresee a potential way to design and develop a nuclear reactor for the economic generation of electric power.

6. It was recognized from the beginning that the ultimate responsibility for building and operating nuclear power stations on a commercial scale in Canada must rest with the electric utilities, which, of course, are not under federal jurisdiction. It was apparent that any nuclear power programme undertaken by AECL as an agency of the federal government must be carried out in close co-operation with the utilities. This led to the conclusion that AECL must be in a position to assist the utilities in evaluating the economic importance of nuclear power in their respective systems.

7. In addition to aiming for an economic nuclear power system that would be an advance on those being developed by other countries, AECL should also develop a type of reactor which would best meet the requirements of those utilities that decided to embark on a nuclear power programme. AECL must be prepared to supply technical advice, experimental and testing services and other assistance in order to help the utilities build and incorporate nuclear power stations in their electricity grids.

8. It must be remembered that it is the function of the electric utilities across the country, whether publicly or privately owned, to

provide the electric power their customers need at the lowest possible price. The customer is not interested in whether the power was generated from water, fossil fuels or from a nuclear reactor. It is up to the electric utilities to decide when they will incorporate nuclear power into their systems and it may be assumed that they will do so when they are satisfied that nuclear power has proved to be reliable, safe and at least as economical as any alternative source and with the potential for being more economical in the years ahead. The type of nuclear power station that is incorporated is a decision for each electric utility.

9. It has also been clear that Canadian industry must be assisted to play its proper role in the construction of nuclear power stations and the manufacture of components for these stations for the domestic and foreign market. This involves the building up in industry of the know-how of the new technology. Several different approaches are possible and the following have been practised for many years:

- AECL reports and papers are distributed to commercial firms that have expressed an interest in receiving them.
- Industrial firms are encouraged to send qualified scientists and engineers to work in AECL establishments so they can gain first-hand experience in the nuclear field.
- Research and development contracts are placed with a large number of commercial firms, through which the firms get training and know-how under

the guidance of AECL staff who are involved and experienced in the work.

Finally, several hundred Canadian firms have been awarded contracts to fabricate or manufacture materials and equipment of use in the atomic energy field.

By this concerted effort substantial and highly qualified industrial development groups have emerged which not only serve the atomic energy business but cannot but help to improve their companies' normal products both technically and economically.

10. Since AECL has the major nuclear energy research and development facilities in Canada and a strong team of experienced personnel, it is natural that one of the responsibilities that has been assumed is the training of scientists, engineers and technical staff. Senior undergraduates, graduates and some university staff members are engaged for summer work at AECL establishments. During their stay they become familiar with the type of work we are doing, and we have the benefit of a closer association with the university community. At the same time our senior staff have the opportunity of observing potential new recruits. University faculty members often continue their own research programmes when they return to university, based on techniques or problems that they have learned during their stay with AECL. In the reverse direction, many university faculties include "alumni" of AECL. It is of interest to note that there are some 60 former AECL staff members now occupying university posts, and most of these are at the department head level. Several hundred highly qualified AECL staff have left to enter industry - 50 have gone to Ontario Hydro alone. While they are missed, we believe

that a turnover of this type is an essential part of AECL's role. We also encourage visits by groups at all levels from high school upwards, besides giving talks and lectures to many organizations and societies as part of a programme of general public education in atomic energy.

11. In the field of radioactive isotopes, AECL has the responsibility of supplying these to Canadian users. This is handled by the Commercial Products group of AECL on normal commercial lines. Since the market in Canada is relatively small, Commercial Products has concentrated on building up an export market in order to handle larger volumes and thereby minimize costs. In this way radioisotopes are available to Canadian users at lower prices than would otherwise be the case. Commercial Products also found many years ago that the market for radioisotopes could be greatly expanded if at the same time special equipment were made available for using isotopes. They were not successful in persuading Canadian industry to do this, so they themselves undertook the design, development and manufacture of associated equipment. This has proved to be most successful. They have supplied more than 600 cobalt therapy units to 48 countries and have recently installed the largest sterilization plant in Europe for medical products. They are currently marketing other equipment such as industrial irradiators that they have designed and manufactured. Last year their revenues were over $9 million, and 90 per cent of this was obtained from outside Canada. Isotopes have wide application in medicine, industry, agriculture, and as a research tool - and the future looks promising.

Appendix 4

STRUCTURE AND ORGANIZATION

The Board of Directors has the full responsibility for the operation of the Company. As required by The Companies Act, an annual Shareholders' Meeting is held for the usual purposes, including the appointment of Directors. The bylaws specify that the term of office of the Directors "shall be for two years from the meeting at which they were elected or appointed or until their successors are appointed." As has been previously mentioned, the Minister is the major shareholder.

2. There are eleven Directors of AECL, but at the present time there is one vacancy owing to the death earlier this year of D. M. Stephens, then Chairman of Manitoba Hydro. The present Directors are -

H. M. Caron	Partner, Clarkson, Gordon & Co., Partner, Woods, Gordon & Co., Montreal
G. E. Gathercole	Chairman, Hydro Electric Power Commission of Ontario, Toronto
Claude Geoffrion	Dean, Science Faculty, Laval University, Quebec City
D. A. Golden	President, Air Industries Association of Canada, Ottawa
J. L. Gray	President, Atomic Energy of Canada Limited, Ottawa
C. A. Grinyer	Consulting Engineer, Caledon, Ontario
J. C. Lessard	President, Quebec Hydro-Electric Commission, Montreal
G. M. Shrum	Co-Chairman, British Columbia Hydro and Power Authority, Chairman, B. C. Energy Board, Chancellor, Simon Fraser University, Vancouver

Appendix 5

H. G. Thode	President and Vice-Chancellor, McMaster University, Hamilton
F. C. Wallace	Chairman of the Board, Canadian Pittsburgh Industries Limited, Duplate Canada Limited, Smith and Stone Limited, Plax Canada Limited, Toronto

It will be noted that the Directors bring to the Board a wide range of experience and background knowledge and that electric utilities, the universities and industry are all represented.

3. Meetings of the Board are held four or five times a year, with an Executive Committee consisting of D. A. Golden, J. L. Gray, H. G. Thode and F. C. Wallace meeting every four to six weeks.

4. The Head Office of AECL is in Ottawa. The Company's main research and development centres are the Chalk River Nuclear Laboratories (CRNL) at Chalk River, Ontario, and the Whiteshell Nuclear Research Establishment (WNRE) at Pinawa, Manitoba. The Commercial Products group of AECL is located at South March, near Ottawa, with a laboratory building at Tunney's Pasture in Ottawa. The Power Projects group is at Sheridan Park, just west of Toronto, with a division at Peterborough, Ont.

5. The basic organization chart of AECL is shown in Table 5A. It will be seen that the heads of the four AECL sites and those with corporate responsibilities report to the President. The organizations of Head Office and of the four sites are shown in Tables 5B, 5C, 5D, 5E and 5F, together with the numbers of employees working in the divisions shown in the organizational charts. The names of the branches that compose the organizational divisions are also shown, to give an indication of the type of work being performed by the divisions.

6. AECL considers itself to be a research and development

organization, while fully recognizing that many of its employees are engaged in supporting activities which are not themselves research and development. These supporting services, whether they be administration, design, marketing or general services, have an essential part to play and AECL, with its present programme and terms of reference, could not operate without them. The employees engaged on these activities are included in the tables. Because of the relatively isolated locations of CRNL and WNRE, AECL is also involved of necessity in activities such as hospital services, the renting of living accommodation and other domestic functions.

7. The number and distribution by organization and category of AECL employees as of 1 August, 1968, were as follows:

	Prof.	Tech.	Admin.	Hr. Rate	Totals
Head Office	19	-	60	-	79
CRNL	466	540	438	978	2422
CP	136	113	152	192	593
PP	242	427	167	-	836
WNRE	130	194	179	213	716
Totals	993	1274	996	1383	4646

8. In the headings of the tables, the expression "Admin." is used to cover the Senate Committee definition "Other Supporting Personnel". "H.R.", for "hourly rate", is used to cover the Senate Committee definition "Workers". The figures include employees such as janitors and security guards; an indication of their numbers can be seen from the divisional breakdowns.

9. AECL Head Office is relatively small. AECL has decentralized as far as is possible, while retaining essential corporate control and control of policies and procedures that must be uniform throughout

Appendix 5

the Company. The Treasurer, the Director of Personnel and the Chief Public Relations Officer conduct centralized activities, recommend policy, give functional direction to the sites and co-ordinate activity in their respective fields. The Nuclear Power Marketing group is in the process of formation and is expected to reach its planned strength of about four or five professional staff in the course of one year.

10. The current organization of the Chalk River Nuclear Laboratories--Canada's original and largest nuclear centre--is outlined in Table 5C. There are three major units--Research, Applied Research and Development and Plant Engineering. A number of senior personnel at Chalk River have been given company-wide responsibilities. For example, Dr. C.G. Stewart, in addition to being Director of the Medical Division at CRNL, is Chief Medica' Officer for AECL.

11. Commercial Products, with its organization shown in Table 5D, is administered as a separate entity within the Company framework and is different in this respect from the other three AECL sites. Greater freedom is given Commercial Products to follow normal commercial practices in its operations.

12. Power Projects is responsible for nuclear power system design, for providing services as a nuclear consulting engineer, for the development and testing of major equipment items for nuclear power stations, and for project management of certain nuclear power stations. Its organization is given in Table 5E. As of 1 July 1968, at the suggestion of Canadian General Electric Company, AECL took over responsibility for the direction and support of the CGE nuclear

engineering group at Peterborough, Ontario. This competent team of about 220 persons remains at Peterborough but is now a division of Power Projects.

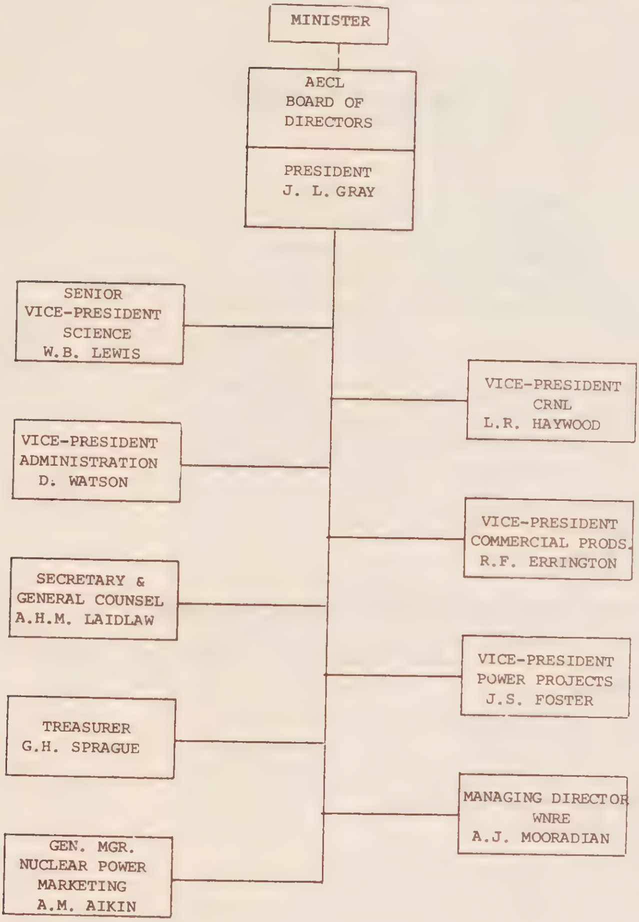
Although it is outside AECL's normal role, AECL was given the responsibility, on behalf of the federal government, for the management of the design and construction of the Nelson River Transmission Line and this is an additional responsibility of Power Projects.

WNRE, Table 5F, is a younger member of the AECL family. In the initial staffing of WNRE many senior personnel transferred from CRNL.

Appendix 5

ATOMIC ENERGY OF CANADA LIMITED

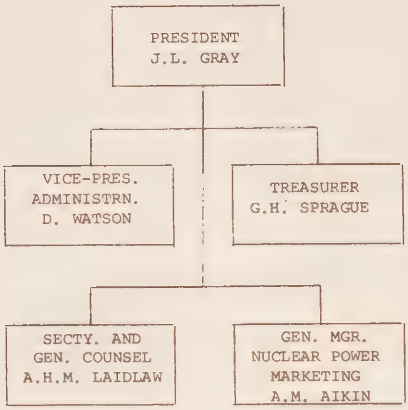
ORGANIZATION - AUGUST, 1968



Appendix 5
Table 5 A

ATOMIC ENERGY OF CANADA LIMITED

HEAD OFFICE ORGANIZATION - AUGUST, 1968



DISTRIBUTION OF HEAD OFFICE STAFF, BY GROUP & CATEGORY

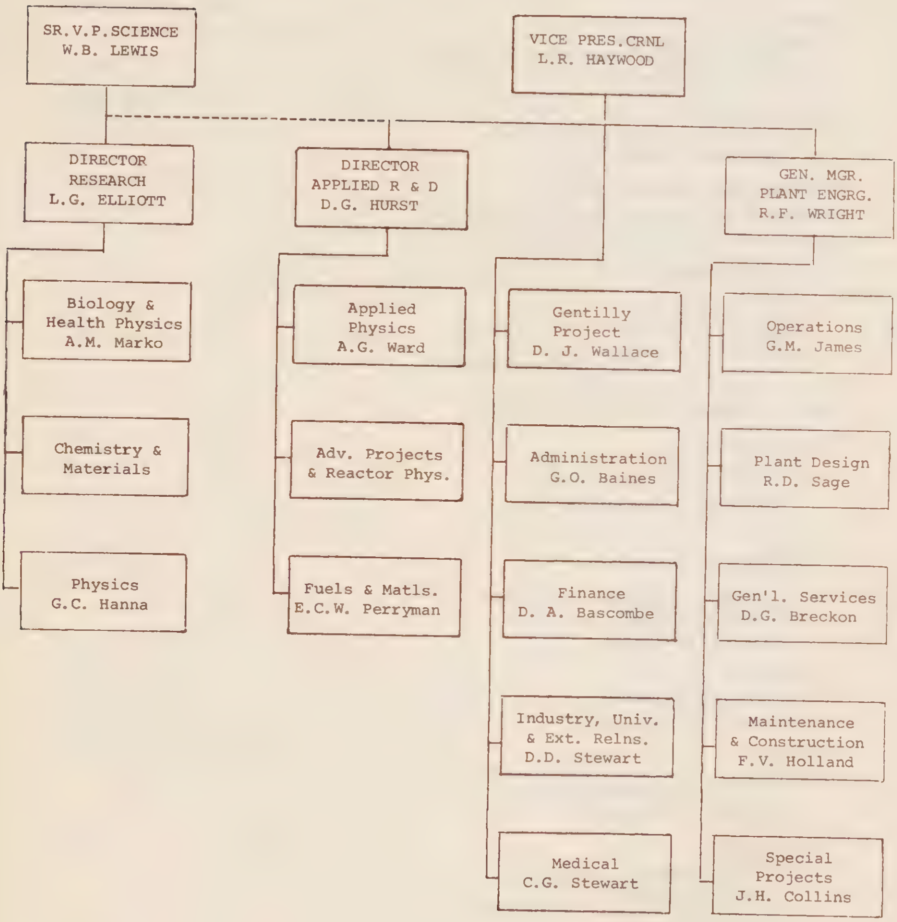
	Prof.	Tech.	Admin.	HR	TOT.
ADMINISTRATION (Personnel, International Affairs, Public Relations, Translation Services)	13	-	12	-	25
FINANCE (Cost & Audit, Gen. Accounting, Data Processing)	3	-	45	-	48
OTHER	3		3		6
TOTAL	19	-	60	-	79

Appendix 5

Table 5 B

ATOMIC ENERGY OF CANADA LIMITED

CRNL ORGANIZATION - AUGUST, 1968



Appendix 5
Table 5 c

DISTRIBUTION OF CRNL STAFF, BY DIVISION & CATEGORY

	Prof.	Tech.	Admin.	HR	TOT
BIOLOGY & HEALTH PHYSICS (Biology; Environmental Research; Health Physics)	22	39	5	8	74
CHEMISTRY & MATERIALS (Research Chemistry; General Chemistry; Materials Science; Metal Physics)	43	60	4	-	107
PHYSICS (General Physics; Neutron Physics; Nuclear Physics; Theoretical Physics; Math. & Computation)	45	50	13	-	108
APPLIED PHYSICS (Accelerator Physics; Proton Beam; Engineering Research)	31	32	6	-	69
ADV. PROJECTS & REACTOR PHYSICS (Advance Engineering; Applied Mathematics; Nuclear Plant Engineering; Reactor Physics; Electronics; Control & Instrumentation)	68	47	14	-	129
FUELS & MATERIALS (Applied Materials Research; Chemical Engineering; Fuel Engineering; Fuel Materials; Metallurgical Engineering)	53	109	7	-	169
GENTILLY PROJECT MANAGEMENT (Montreal)	1	-	6	-	7
ADMINISTRATION (Personnel; Public Relations; Staff Development & Welfare; Technical Information)	19	2	138	-	159
FINANCE (Accounting; Stores)	2	-	34	20	56
INDUSTRY UNIV. & EXTERNAL RELATIONS (Industry Relations; University & External Relations)	3	-	2	-	5
MEDICAL (Deep River Hospital; Plant Hospital; Medical Research)	4	41	10	12	67
OPERATIONS (Chemical Operations; NRU Reactor; NRX Reactor; Reactor Loops; Reactor Technology)	76	26	18	153	273
PLANT DESIGN (Civil & Mechanical Design; Design & Technical Service; Mechanical Equipment Development; Process Systems)	43	89	16	-	148

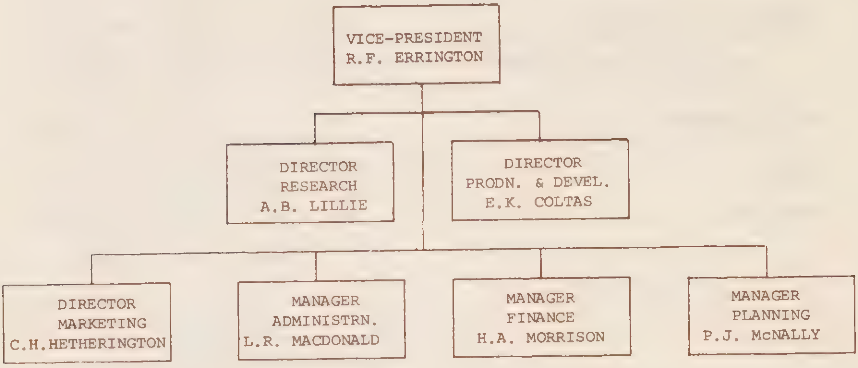
Appendix 5
Table 5 C (contd)

	Prof.	Tech.	Admin.	HR	TOT
GENERAL SERVICES (Deep River Administration; Protective Services; Purchasing; Radiation & Ind. Safety; Transport)	8	36	77	267	388
MAINTENANCE & CONSTRUCTION (Electrical, Instrument & Power; Mechanical Services; Workshops Estimating & Planning)	26	4	69	518	617
SPECIAL PROJECTS (Nuclear Materials Control)	5	4	13	-	22
OTHER	17	1	6	-	24
CRNL TOTAL	466	540	438	978	2422

Appendix 5
Table 5 C (contd)

ATOMIC ENERGY OF CANADA LIMITED

COMMERCIAL PRODUCTS ORGANIZATION - AUGUST, 1968



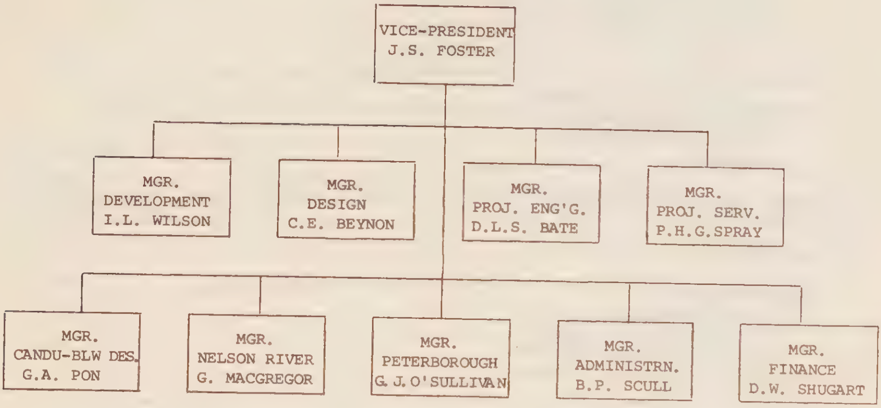
DISTRIBUTION OF STAFF BY DIVISION AND CATEGORY

	Prof.	Tech.	Admin.	HR	Total
RESEARCH (Food Irradiation; Neutron Applications; Energy Sources; Medical Application; Industrial Metrology; New Materials)	29	28	8	-	65
PRODUCTION & DEVELOPMENT (Equipment Production; Isotope Production; Quality Control; Development)	55	77	28	151	311
MARKETING (Medical Products; Industrial Products; Product Planning; Market Analysis; Sales Promotion; Installation & Service)	37	6	29	-	72
ADMINISTRATION (Purchasing; Personnel; Radiation Hazards & Safety Control; Building Engineering; Public Relations; Library)	7	2	35	24	68
FINANCE (General Accounting; Budgets & Cost Accounting; Order Processing; Stores & Materials)	2	-	31	17	50
PLANNING (Management Services; Data Processing)	3	-	18	-	21
OTHER	3	-	3	-	6
CP TOTAL	136	113	152	192	593

Appendix 5
Table 5 D

ATOMIC ENERGY OF CANADA LIMITED

POWER PROJECTS ORGANIZATION - AUGUST, 1968



DISTRIBUTION OF STAFF BY DIVISION

	Prof.	Tech.	Admin.	HR	Total
DEVELOPMENT (Physics & Analysis, Systems Analysis; Reactor Physics Safety, Shielding & Mechanics)	47	125	7	-	179
DESIGN (Station Control; Reactor Design; Process Control; Reactor Processes; Fuel Handling Control; Fuel Handling; Design Co-ordinator; Auxiliary Processes; Drawing Office; Layout & Structures)	112	232	35	-	379
PROJECT ENGINEERING (Pickering Project Engineer; Rajasthan Atomic Power Project Engineer; Douglas Point Project Engineer; Planning & Scheduling Engineer)	6	10	3	-	19

Appendix 5
Table 5 E

	Prof.	Tech.	Admin.	HR	Total
PROJECT SERVICES (Reactor Components Contracts & Quality Control; Process Systems Contracts; Instrumentation Contracts & Project Estimates; Material Control & Contract Administration)	16	11	27	-	54
CANDU-BLW DESIGN (Mechanical Drafting; Systems; Control, Instrumentation & Electrical; Structures & Services)	40	36	18	-	94
NELSON RIVER TRANSMISSION FACILITIES (Nelson River Project)	3	-	2	-	5
PETERBOROUGH*	2	-	-	-	2
ADMINISTRATION (Standards & Publications Branch; Purchasing Agent; Public Relations; Personnel; Plant Engineering; Library)	8	13	63	-	84
FINANCE	1	-	8	-	9
OTHER	7	-	4	-	11
PP TOTAL	242	427	167	-	836

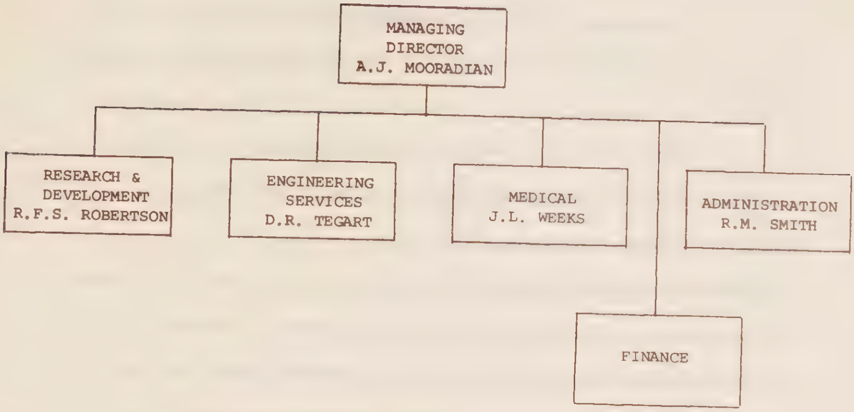
*These figures do not include CGE personnel attached to Power Projects, Peterborough Office. Figures for these personnel shown in Appendix 10, Table 10A.

Appendix 5

Table 5 E (contd)

ATOMIC ENERGY OF CANADA LIMITED

WNRE ORGANIZATION - AUGUST 1968



DISTRIBUTION OF WNRE STAFF, BY DIVISION & CATEGORY

	Prof.	Tech.	Admin.	HR	Total
RESEARCH & DEVELOPMENT (Reactor Core Technology; Material Sciences; Chemical Technology; Assessment, Comput. & Instrumentation)	54	112	10	-	176
ENGINEERING SERVICES (Operations; Maintenance; Design & Project Engineering; Reactor Technology)	54	44	46	171	315
ADMINISTRATION (Finance; Purchasing; Pinawa; Personnel; Technical Information; Stores; Public Relations; Protective Services)	6	-	113	33	152
MEDICAL (Health & Safety)	15	38	9	9	71
OTHER	1	-	1	-	2
WNRE TOTAL	130	194	179	213	716

Appendix 5
Table 5 F

AECL'S RELATIONS WITH OTHER ORGANIZATIONS

With other federal agencies

In carrying out its responsibilities and functions AECL needs to have close relations with several other federal agencies.

2. AECL scientists keep in touch with their opposite numbers working in allied fields in the Department of National Health and Welfare, the National Research Council, the Department of Agriculture, the Defence Research Board and the Department of Energy, Mines and Resources. Because no scientist knowingly undertakes a line of research identical to that already being pursued by some other scientist, except for very good reasons, there is less duplication than one might expect from a study of organizational inter-ties. However, from time to time a special and independent review of a field is worthwhile. At present AECL believes (and has so recommended) that such a review is desirable in the field of radiobiology, so that the various government departments and agencies working in this area may be satisfied that their present and proposed programmes fit reasonably into an over-all programme.

3. As would be expected, AECL has a close working relationship with the Atomic Energy Control Board, a sister organization reporting to the same Minister. The AECB would be the first to acknowledge the value of technical advice and experience obtained from AECL working scientists and engineers in assisting the Board in its licensing and regulatory functions. The President of AECL is a member of the Control Board and AECL staff are members of certain AECB Advisory Committees.

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4. In Canada health and safety matters are normally the responsibility of provincial authorities. However, in the field of atomic energy matters generally the governing legislation is the Atomic Energy Control Act, and the regulations thereunder are administered by the AECB. The Board, while providing licence and regulatory authority for all nuclear installations in Canada, regards AECL as responsible for the maintenance of proper health and safety conditions in all operations at AECL sites. The limits applied by AECL are within those set out in the Atomic Energy Control Regulations.

5. AECL and the Department of Industry have a common objective of getting Canadian industry better equipped and better qualified in new technologies. AECL has an additional selfish motive for wanting Canadian industry to excel in building components for nuclear power stations: the success of the Canadian nuclear power programme depends as much on the quality and timely delivery of equipment produced as it does on the concepts and basic technology developed by AECL.

6. In the field of patents AECL has engaged Canadian Patents and Development Limited to handle most of its patent work. CPDL reviews inventions, searches existing patents, and files patent applications for AECL when appropriate. They also exploit issued patents and know-how, except in the areas of nuclear power and radioisotopes.

7. There are close relationships between AECL and the Department of External Affairs, since AECL has many overseas interests. Some of the subjects involved are the negotiation

of government-to-government agreements relating to the peaceful uses of atomic energy, liaison with the many governments that have an interest in atomic energy, the activities of the International Atomic Energy Agency and other international organizations such as EURATOM and the European Nuclear Energy agency, questions regarding international safeguards, and other matters that affect AECL such as the Non-proliferation Treaty. It should be mentioned that Canada is represented on the Board of Governors of the International Atomic Energy Agency in the capacity of being one of the five nations "most advanced in the technology of atomic energy, including the production of source materials," and this allows Canada to take a much higher place in a world forum than is normal for a country of her size.

8. In the field of overseas marketing the Department of Trade and Commerce and the Export Credit Insurance Corporation are able to provide services that assist AECL and Canada. Mention should be made of AECL's relations with the Department of Finance, the Treasury Board and the Auditor General, whose advice is frequently sought and is highly regarded.

With industry

9. Over many years AECL has encouraged and fostered participation by Canadian industry in Canada's nuclear programme. To help in maintaining and expanding AECL's relationships not only with industry but with universities as well, there is a division of AECL set up to handle, co-ordinate and maximize these relationships.

10. The most direct means of assisting industry is AECL R&D contracts, which in 1967-68 totalled approximately \$6 million and involved some 40 companies. An additional \$7.2 million was spent in the private area on various professional and consulting services.

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11. High priority is given by AECL to development work contracted with industry, since this has proved to be one of the most effective ways of qualifying Canadian companies to supply services, materials and equipment that will meet the stringent demand of the nuclear environment and of preparing them to meet the requirements of the expanding nuclear power programme.

12. One of the most successful programmes has been the development support given to two Canadian companies which are now established as highly qualified and commercially competitive nuclear fuel manufacturers and suppliers.

13. Another example of AECL development support is an existing contract aimed at the commercial production of zirconium alloy pressure tubes in Canada. By 1973 the estimated requirements for such tubes are valued at $2.6 million per annum, made from ingots valued at $1.5 million.

14. Companies of all sizes are encouraged to participate and to initiate work in advanced technologies. Such work provides industry personnel with valuable training and experience and establishes a base for future commercial exploitation. Companies interested in specific projects of a co-operative nature are encouraged to send staff to AECL establishments for extended periods. Many have done this and, on the average, there are 35 such attached staff with AECL on a continuing basis.

15. As regards the design of a nuclear part of a nuclear power station, AECL has assumed the responsibility of ensuring that there is a capability in Canada to meet the needs of the electric

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utilities. Over the years several different approaches have been taken, and the present system has evolved by experience. For one nuclear reactor a consulting engineer was engaged, for another nuclear reactor a manufacturer/designer was given prime responsibility and, based on first-hand experience gained from these arrangements coupled with the position taken by the client, the electric utilities, AECL itself assumed responsibility for the design of the nuclear portion of nuclear power stations. However, AECL has attempted to utilize as much engineering assistance from commercial consultants as is practicable, bearing in mind that AECL has to be responsible for the complete system. In the case of the design of the 250,000 kilowatt prototype nuclear power station AECL is building for incorporation into the electricity grid of Hydro-Quebec, the distribution of the design engineers engaged on the project is of interest:

At AECL Sheridan Park		At Consultant Office	
AECL	30	Consultant	55
Hydro-Quebec	9	Hydro-Quebec	2
Consultant	21		—
	60		57

It will be seen that of the 117 design engineers only one-quarter are AECL staff.

16. Ten years or so ago AECL assisted the Canadian General Electric Company in setting up an atomic energy department, and several senior AECL staff transferred to CGE to form the core of the new organization. In subsequent years the team grew in size and competence and became highly qualified.

<u>Appendix 6</u>

Unfortunately, in spite of CGE efforts, this organization was unable to maintain a viable operation and in the spring of 1968 CGE informed AECL that they were not prepared to carry on and suggested that a merger with AECL would be in the best interests of CGE, AECL and Canada. A formal contract between CGE and AECL was entered into on 1 July 1968 by which the CGE design team became a division of AECL Power Projects. The agreement is for a term of five years, with an appropriate termination clause.

17. It has been emphasized to Canadian utilities, manufacturers and consultants on many occasions that it is not AECL's intention to stay permanently in the nuclear power station field. It is necessary, however, for the demand for work to expand considerably before a change is made and two separate design teams can anticipate a promising future. It must be remembered that the competition abroad is from huge organizations such as General Electric and Westinghouse in the United States, the United Kingdom Atomic Energy Authority in Britain and Siemens in Germany.

18. Another influencing factor is the rapidly increasing size of individual nuclear power stations. Where at one time it was expected the power demand would be satisfied by small nuclear stations, supplied by several organizations, the demand now is for fewer but larger units. Even the United Kingdom found it could not maintain three commercial consortia, which faced alternating feast and famine conditions, so a major consolidation and reorganization is now taking place.

Appendix 6

With educational institutions

19. As a matter of policy AECL does not make awards or issue grants in aid of university research. In the atomic energy field such grants are administered by the AECB and by NRC. AECL, however, does support research in universities under research contracts, the distinction being that the work done under a research contract is something that AECL needs to have done for its programme. Arrangements are worked out for the mutual benefit and satisfaction of both parties. Usually AECL makes inquiries of university faculty members known to have expertise in fields of interest to AECL. The formal contract is with the university on an annual basis, subject to extension depending upon the success of the programme and availability of funds. Usually the work extends over three to five years. The volume and value of these contracts have grown steadily to the present annual amount of about $750, 000. Some 20 different universities in all parts of Canada are involved.

20. Close ties with universities are also maintained through personal contacts and a two-way flow of staff for lectures, seminars and discussions. During the summer months it is normal to have more than 100 graduates and undergraduates working at AECL establishments. A number of professors also spend the summer months making use of specialized AECL facilities for research projects. Their observations on AECL research programmes are also valued. AECL is proud that some 60 former AECL staff members are now occupying university positions in Canada and that many of these are department heads.

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21. For many years university use of AECL's unique facilities was arranged on an informal ad hoc basis. By 1967, however, the utilization and interest on the part of the universities had increased sufficiently to suggest that the programme be given more formal status. An Experiments Advisory Committee was formed, consisting of four AECL staff and four university staff, to assist in the co-ordination and supervision of experimental programmes carried out by university staff at the Chalk River Nuclear Laboratories.

With atomic energy programmes outside Canada

22. In the conduct of her atomic energy programme Canada has developed international associations which have spanned a quarter century in time and have embraced all continents. Perhaps no other area of scientific activity has given rise to such extensive collaborations and certainly few, if any, have provided the same degree of international recognition.

23. It is quite natural that importance be attached to co-operative programmes, for Canada's atomic energy activities were initiated through collaborative ventures of British and French scientists who with Canadian colleagues laid the foundation for Canada's atomic energy programme.

24. Today some 50 countries have operating nuclear reactors of one type or another. AECL has direct contacts with many of these countries and is linked with most of the others through various international organizations. In this way fruitful

exchanges of information and practical co-operation are possible. AECL's scientific reports are sent to more than 250 libraries in 44 countries and it receives over 12,000 technical reports from other organizations each year. It is normal to have scientists and engineers from a dozen different countries attached to AECL for training or collaborative programmes. AECL staff attend many technical meetings and visit a large number of atomic energy organizations in other countries each year.

25. The International Atomic Energy Agency has for many years been an important focus and AECL regularly has representation on its study groups and advisory panels.

26. AECL Directors and senior staff hold annual review meetings with their opposite numbers of the United Kingdom Atomic Energy Authority, the United States Atomic Energy Commission and the French Commissariat a l'Energie Atomique, to review their respective nuclear power programmes and to discuss desirable areas of collaboration.

27. Special mention should be made of the close relationships that have been established with the Department of Atomic Energy in India. Canada built, under the Colombo Plan, an updated version of the Chalk River NRX reactor known as CIRUS, near Bombay, which has been successfully operating since 1960. A nuclear power station with a pair of 200,000 kilowatt reactors similar to that of the Douglas Point station in Ontario is now under construction in India with ECIC

Appendix 6

financing. Full detailed design was provided by AECL under a government-to-government agreement, with the object of helping India become as self-sufficient as possible in nuclear power technology. Indian manufacturers are being trained and are being used to the maximum extent possible so that the "technology gap" can be reduced. AECL Power Projects is acting as the consulting engineer for the nuclear portion of this station, and Montreal Engineering Company has been engaged by the Indians as the engineering consultant for the conventional portion.

28. AECL's Senior Vice-President Science, Dr. W. B. Lewis, has for many years been a member of the Scientific Advisory Committee of the Secretary General of the United Nations and is also a member of the Scientific Advisory Committee of the International Atomic Energy Agency.

29. AECL has several agreements for co-operation with other atomic energy organizations abroad, such as those of the USA and the USSR, and a number of other commercial agreements. For a number of years both the USAEC and the UKAEA have made extensive use, on a rental basis, of the NRX and NRU reactors.

30. AECL maintains one overseas liaison officer; he is attached to the United Kingdom Atomic Energy Authority.

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General

Many AECL employees are active members of panels and committees of local, national and international organizations. At CRNL, for example, more than 100 employees annually contribute approximately 2,070 man-days to these commitments. There are 56 employees who devote about 760 man-days to international organizations involved in scientific and technical matters (OECD, IAEA etc.). Another 40 contribute some 650 man-days to similar organizations in Canada. About the same number give about 660 man-days of time to the betterment of education and the maintenance of professional standards.

32. In addition to the above, AECL frequently assigns professional staff to international organizations for extended periods of time. This amounts on the average to about 300 man-days per year.

Appendix 6

ORGANIZATIONAL POLICIES

It has already been mentioned that AECL is decentralized. Responsibility is given to site heads to operate their establishments within Company policies and procedures and under the direction of the President. When a new policy or procedure is desirable, it is discussed by any site affected and Head Office before a directive is issued. In this way, all concerned have warning and Head Office has the benefit of prior comments from those who have to administer the new policy or procedure.

2. Each site has its own supporting services such as personnel, finance and workshops. Liaison between sites is on a daily basis. Scientists and engineers are expected to consult not only within their own site, but with other AECL sites as well. There are several inter-site committees set up to allow sharing of experience and discussion of common problems. The senior committee, known as the Senior Management Committee, is chaired by the President and meets monthly.

3. At each site, the staff is usually organized into divisions which contain 30 to 70 professionals. At CRNL and WNRE they are usually formed of staff of the same discipline and fields of interest rather than as specific project teams.

4. Every effort is made to avoid the creation of water-tight compartments. Staff are encouraged to become knowledgeable of developments in fields other than their own. They are encouraged to express their thoughts and they receive a good hearing. On the other hand, they are expected to follow direction; most of AECL's work involves teamwork and someone has to be in charge. In this sense, AECL is more similar to an industrial laboratory than to

a university.

5. There are several processes whereby AECL's operational effectiveness, duties and goals are reviewed and revised and these are done in parallel and on a continuing basis. Senior management and working scientists and engineers are constantly aware of the need to review progress to ensure that the work being performed is the most useful and effective.

6. Quarterly progress reports written by staff of all divisions describe in depth the accomplishments of the preceding three-month period. This forces the individual scientist to review his work and enables division heads and senior management to follow and evaluate individual programmes.

7. The annual budget preparation and submission also provides for a critical review of expenditures related to programme effectiveness.

8. Each completed phase of a research and development project is written up as an AECL report or as a journal publication which is then open to critical review by experts in the field.

9. Senior management personally make first-hand reviews of programmes under their direction on a continuing basis.

10. In some broad areas involving inter-related work there are formal review committees. As an example, there is the Power Reactor Development Programme Evaluation Committee chaired by the Senior Vice-President, Science, which reviews in detail the existing programme and proposals for extensions or additions relating to power reactor technology.

11. AECL staff make presentations at many national and international conferences at which time the effectiveness of the work or

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programme is open to outside criticism.

12. AECL's co-operative development programmes, particularly with the US Atomic Energy Commission and the UK Atomic Energy Authority, result in frequent reviews of the individual programmes and their effectiveness. At the same time, essential short-term goals and objectives are reviewed and confirmed.

13. In some fields computer programmes can be used as powerful tools for measuring costs and savings. This is particularly true in the development of reactor components and in the design of reactor systems. Computer programmes have been developed to assess what changes in capital costs or unit energy costs would result from specific development objectives. These provide a measurement of success achieved and point to projects worth further development.

14. Inherent in AECL's organization is great flexibility for change; the emphasis on projects can be altered quickly and efficiently as necessary.

15. Outside studies of AECL organization commissioned during the past five years have been a survey of the functions of AECL Head Office in relation to AECL sites and a study of the organization of Commercial Products.

16. AECL's activities and programmes are all within the powers and responsibilities assigned to AECL, but as has been mentioned previously, AECL is not engaged in several activities that could be covered by its powers. AECL has not attempted to embark on research and development in the whole field of atomic energy, but has concentrated on specific areas that are either

judged to be of economic importance in the near future or are in areas of fundamental research in which AECL has built up competence and expertise.

17. The major hindrance to the performance of AECL's functions is the problem of obtaining the financial support needed to carry promising projects through the expensive but critical stage of prototype development. The nuclear power stations that are now committed or are on the planning boards--in Canada and elsewhere--are so big and require so much capital that the utilities are reluctant, understandably, to adopt major system changes developed in the laboratories unless the gains can be firmly established. The utilities want proof of the economic and technical advantages of advanced nuclear systems before committing themselves to the heavy investments involved in new designs; only in prototypes can proof be obtained.

18. In another instance, nuclear fuel reprocessing appears to be a promising new major industry, but adequate pilot plant development and construction has to be carried out before industry can be expected to invest in a full-scale reprocessing plant. Working through the prototype stage would cost a million dollars or more but the potential business is likely to be in the region of \$15-\$20 million per annum within a couple of decades.

19. No major changes in organizational functions during the next five years can be forecast at the present time. Howevei, major organizational changes have taken place within AECL every few years so a future change would not be unexpected.

<u>Appendix 7</u>

PERSONNEL POLICIES

The steps taken to identify and hire those members of university graduating classes who will be the most effective research workers in AECL depend to some extent on whether the research worker will be engaged in science or in engineering. In science, AECL hires mainly at or after the Ph. D. level at which time the scientist will already have achieved some reputation in the field in which he is interested and have firm ideas on the type and areas of work in which he wishes to be employed. On the other hand, for engineering the majority of research workers are engaged at the master or bachelor level.

2. As shown in Table 10H Appendix 10, not all new employees are new graduates. Apart from other considerations, the hiring of replacements who have had experience elsewhere is revitalizing and prevents "in-growth".

3. Professional staff from graduating classes come to the attention of AECL by having been summer students, by having worked on AECL research contracts, by having used AECL facilities, by having their professors refer them to AECL, or by contact during annual AECL recruiting tours to universities. University visits are advertised and graduating students in disciplines of interest to AECL are interviewed. If a candidate appears to be well qualified on paper and the interviewer feels he has good potential, the appropriate faculty members are asked for their opinion of him and his suitability for the designated position. If the response is favourable, he is considered along with other qualified applicants before being given a firm offer of employment.

Contact is made by mail with Canadian post graduate students working in Britain and the U. S. and AECL depends on NRC records to supply their academic qualifications. AECL follows up with interviews and solicits references from the faculty members under whom the post graduates are working.

4. The greater the extent of post graduate research experience, the more reliance is placed on references from university faculty members. At the undergraduate level, academic performance and personal interviews are the primary factors of the assessment.

5. There has not been any research initiated to develop criteria to help identify those who will become creative and effective research workers. It is questionable whether any standards that would be effective and reliable could be established. Strong reliance must be placed on personal judgment backed by references both formal and informal. Initial appointments are carefully reviewed and must be approved by site committees or AECL Boards which are representative of diverse interests.

6. The best assessments of a research worker are those provided by his peers--working scientists in his own field. An early test of potential, often applied soon after recruitment, is to require a research worker to formulate a considered written programme of work covering his activities for the next two to five years. This also has the merit of helping a new research man become an effective member of a research team.

7. Annually, each individual research worker is reviewed in detail within his own division for his accomplishments, ability and potential. These merit reviews are conducted next at the

AECL site level and finally by a company-wide AECL Board. Over the years this system has been very successful in identifying good research workers. Basic criteria for judgments are quality and value of work done, individual drive, initiative and the ability to communicate. It has been found that persons with the qualities of leadership needed to direct research programmes emerge through their acceptance of responsibilities and are not difficult to identify quite early in their careers.

8. In AECL no distinction is made in value between administrative and technical capability and responsibility. A scientist does not have to accept administrative responsibilities in order to receive promotion. Individual research workers may advance through grades to a salary of over $20,000 per annum without having to accept administrative responsibilities.

On the other hand, it is normal for research and development scientists and engineers who have not only the capability of doing individual work, but have the personal qualities to be research directors, to be appointed to senior management positions at the division head level or higher that involve administrative duties as well as scientific direction.

9. A continuing effort is made to have supporting teams perform as many administrative functions as possible so as to allow scientific division heads the maximum time to operate in their fields of technical competence. The majority of senior AECL staff who are engaged in straight administrative work received their early training as scientists or engineers and this enables them better to appreciate the needs of the research workers and provide support with greater understanding.

Appendix 8

10. AECL has several procedures to encourage the further education of staff members. Regular seminars, lectures and less frequent intramural courses are given. AECL provides financial assistance toward job related courses and has a programme of assistance for professional employees to help them return to university to obtain higher degrees. For those already at the post doctoral level, special "summer schools" to learn new techniques and developments are of special interest and AECL is prepared to encourage attendance. From time to time, arrangements are made for a research scientist to work at another laboratory, usually abroad, to gain wider experience and learn new techniques.

11. Perhaps the most valuable education for research directors is through communication with others in different laboratories throughout the world. Owing to AECL's international commitments and connections, such staff often travel widely and are able to benefit in this manner without any formal policy.

12. It might be mentioned that a large percentage of the AECL professionals directly engaged in R&D have engineering degrees. At Chalk River the figure is 40 per cent.

Appendix 8

DISTRIBUTION OF ACTIVITIES

AECL has four operating establishments, three of which are in Ontario and the fourth in Manitoba. There is also a small office in Montreal to handle the administration of the nuclear power station AECL is building near Gentilly in the province of Quebec and one in Winnipeg for management of the Nelson River transmission line project.

2. The location of the Chalk River Nuclear Laboratories was chosen during the Second World War to meet the requirements of an isolated area (for security reasons), an abundant power and water supply, and reasonable access to Ottawa.

3. Commercial Products was already in Ottawa as part of Eldorado Mining and Refining Limited (now Eldorado Nuclear Limited) when taken over after the incorporation of AECL. The location was convenient to a supply of skilled labour, transportation facilities and other federal research and development organizations such as NRC, Department of National Health and Welfare and what was then the Mines Branch. The Chalk River Nuclear Laboratories from which Commercial Products obtained supplies of radioactive materials were not too far away.

4. When Power Projects was established, it was decided that the primary requirement was to have close access to major engineering and manufacturing firms since considerable liaison would be required in the design and development of materials, equipment and components for nuclear power stations. The Toronto area was chosen in preference to other major industrial centres because of Ontario Hydro's greater

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expression of interest in nuclear power than those of other Canadian electric utilities. AECL had invited all Canadian electric utilities to propose an arrangement for collaborative construction of the first nuclear power station in Canada. Ontario Hydro's offer, which included provision of a site and supply of the conventional part of the nuclear power station, was the best received.

5. AECL considered that a research and development centre such as Chalk River would be most effective if it were limited in size to about 2,500 employees. Rather than have Chalk River gradually expand to a greater size, it was decided that a new establishment should be formed and allowed to grow. After a review of federal government research and development organizations across the country, AECL decided that for the general well being of science and technology in Canada, a location in the province of Manitoba would be desirable. The actual location at Pinawa was worked out between the federal and Manitoba governments.

6. For nuclear research establishments there are certain requirements such as a relatively large area for a safety exclusion zone, large quantities of cooling water for research reactors, good communications for liaison with industry, universities and other research establishments and proximity to industrial areas to provide labour, engineering and construction support, materials and supplies and other services.

7. The success of a research establishment depends very largely on the ability to obtain and retain first-rate professional staff possessing enthusiasm and motivation. If it does not exist already, the proper environment must be created in order to attract such

people. Besides a suitable working environment, they require in the neighbourhood good schools for their children, hospital and medical facilities and adequate housing. Without the provision of these environmental conditions, AECL could not have maintained CRNL and WNRE as high quality research establishments.

8. AECL has not been involved in programmes to assist in the investigation of regional problems or phenomena. AECL's development of nuclear power reactors and of the application of radioisotopes is to meet the requirements of all regions of Canada although some regions will have greater and earlier need than others. Since nuclear power stations need not be sited near supplies of fuel, they can be placed in close proximity to areas of electricity demand. In due course, this should help the avoidance of too great a concentration of industrial activity.

9. AECL's Chalk River Nuclear Laboratories and Whiteshell Nuclear Research Establishment have made a marked contribution to the development of the regions surrounding them. Many people from neighbouring communities have been employed in the construction and operation of the buildings and facilities and the salaries and wages of AECL employees have clearly had significant effect on the local communities. Craftsmen and technicians have learned new skills and apprentices have been trained. Engineering firms and supply sources have obtained new business. The presence of WNRE in Western Canada has had a noticeable effect on AECL's contacts with western universities and in enabling western firms to obtain a fuller share of the business arising from AECL's activities.

10. AECL's decentralization has not resulted in any apparent loss of efficiency. On the other hand, several benefits have accrued

such as the acquisition of skilled and semi-skilled workers from different regions in Canada, closer proximity to a wider range of industry and consultants, and the maintenance of better liaison with engineering and scientific staff throughout Canada.

Appendix 9

PERSONNEL STATISTICS

The present number of employees in AECL divisions is given in Appendix 5. The personnel establishments and strengths of AECL sites as of 1 August 1968 are given in Table 10A.

2. Those in AECL who have management and senior administrative responsibilities have professional backgrounds and are listed as professional staff. The number of professionals who are primarily engaged in administrative and management duties are -

Head Office	-	19
CRNL	-	32
CP	-	16
PP	-	10
WNRE	-	7

3. In the research divisions it is common practice to have a professional reporting to the division director in a staff capacity to handle administrative matters of the division such as personnel, purchasing, budget preparation and control thereby allowing the division director to concentrate on the technical direction of his programme.

4. Data on the educational backgrounds of AECL professional staff and other personal history statistics are given in Tables 10B to 10E. Other personnel statistics are given in Tables 10F to 10H. In Tables 10B to 10H data on only those professionals who are primarily associated with scientific activities have been recorded since these are considered to be more relevant.

5. The percentage of professionals able to operate effectively in Canada's two official languages is not high at any AECL site. For many years AECL has attempted to recruit francophone professionals, but with little success, one obvious reason being the scarcity of

French-speaking scientists. There is also a reluctance to work in Ontario and Manitoba. Our efforts are continuing. The English-speaking professionals unfortunately rarely find a need or opportunity to converse in French in the course of their work. Most are able to understand technical papers written in French. It is a fact that a majority of the world literature in atomic energy is written in English, and English is the normal language used in international technical discussions even in continental Europe. As a result, no one can expect to reach a senior position in international atomic energy circles without being proficient in both written and spoken English. This is recognized by those who have other mother tongues and they therefore practice English whenever they can.

6. The experience and background of AECL professional staff are quite varied. Table 10H shows that a high percentage have worked in industry since graduation.

7. Financial assistance is provided by AECL to professionals who wish to return to university to obtain a higher degree. The number of employees receiving such assistance at any one time is limited to 10. Those who avail themselves of this opportunity receive a monthly allowance and travel costs rather than full pay. In August 1968 the following numbers were on leave under this programme:

	Bachelor	Master	Total
CRNL	3	2	5
CP	-	1	1
PP	1	1	2
WNRE	-	1	1
			9

8. A similar programme has been introduced this year for non-professional employees by which they will have the opportunity

Appendix 10

of improving their educational qualifications through full-time attendance at technological institutes or universities. Several applications for assistance under this new procedure are being processed.

9. Employees who receive allowances from AECL while attending full-time courses are expected to return to AECL on the completion of their studies.

10. Occasionally a member of staff goes to work at a university on an individual research project, but this is not considered to be educational leave.

11. The numbers of university students given summer employment in scientific activities by AECL in 1962-67 were:

	CRNL	CP	PP	WNRE	TOTAL
1962	85	2	4	3	94
1963	78	-	5	3	86
1964	94	8	6	9	117
1965	96	8	6	14	124
1966	99	6	7	24	136
1967	95	6	8	28	137

AECL also supports the co-operative training programmes of the University of Waterloo and the University of Sherbrooke. These programmes offer work-terms of four months in industry, alternating with four-month periods of study at the university.

12. Employees of AECL have come under the Industrial Relations and Disputes Investigation Act since 1952, when AECL was incorporated. Nearly all of the hourly rate workers and a substantial proportion of the technical and supporting staff are represented by unions and are under collective agreements. Some 20 different local unions are currently recognized as bargaining agents for specific groupings of AECL employees

and there is at least one union at each AECL site other than Head Office. No AECL professional staff are unionized, but societies of professional employees have been formed at CRNL and at WNRE and they make informal representations to management from time to time.

13. Salary scales for all non-unionized staff are reviewed annually and adjusted as appropriate to ensure that they are competitive. All adjustments are announced before changes become effective--in other words there is no back-dating of salary scale increases. In determining adjustments to the professional scales, the primary criteria are the salaries paid to scientists and engineers by the major Canadian industries and Canadian universities and the salaries paid to those doing comparable work in other federal government agencies.

14. Merit increases for most AECL professional staff are determined by site management within a "merit package" allotted to each site each year based on the composition of the professional employees at the site.

Appendix 10

CURRENT PERSONNEL ESTABLISHMENT AND STRENGTH BY SITE

Strength Figures as of August 1, 1968

	PROFESSIONAL		TECHNICAL		ADMINISTRATIVE		HOURLY RATE		TOTAL	
	EST.	STRENGTH	EST.	STRENGTH	EST.	STRENGTH	EST.	STRENGTH	EST.	STRENGTH
CRNL	500	466	555	540	402	438	1006	978	2463	2422
Attached Staff		67								
Post-Doctorate Fellows		10								
CP	165	136	147	113	163	152	215	192	690	593
Attached Staff		-								
Post-Doctorate Fellows		-								
PP	330	242	456	427	194	167	-	-	980	836
Attached Staff		44								
Post-Doctorate Fellows		-								
CGE Employees		93		100		27				
WNRE	173	130	245	194	201	179	267	213	886	716
Attached Staff		7								
Post-Doctorate Fellows		4								
TOTAL*	1168	974	1403	1274	960	936	1488	1383	5019	4567

* Totals do not include Attached Staff, Post-Doctorate Fellows, and CGE employees

Appendix 10

Table 10A

AECL PROFESSIONAL STAFF BY COUNTRY OF BIRTH, COUNTRY WHERE SECONDARY EDUCATION WAS TAKEN; AND COUNTRY IN WHICH UNIVERSITY DEGREE TAKEN

	I				II				III			
Country and Degree Category	Country of Birth				Country in which Secondary Education is taken				Country in which University Degree is taken			
	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP
CANADA												
1) Bachelor	159	59	21	28	171	63	21	29	304	87	32	57
2) Masters	44	10	6	21	47	8	6	23	106	19	6	22
3) Ph.D	76	11	2	2	81	11	2	3	53	13	1	3
U.K.												
1) Bachelor	76	11	6	17	72	10	6	17	135	32	10	19
2) Masters	12	7	1	1	14	9	1	1	27	13	4	5
3) Ph.D	46	17	3	-	46	17	3	0	59	17	3	-
U.S.A.												
1) Bachelor	5	-	3	-	2	-	3		7	5	1	3
2) Masters	1	-	-	1	-	-	-		9	5	3	4
3) Ph.D	2	4	-	-	-	4	-		19	8	1	1
INDIA												
1) Bachelor	-	-	1	2	-	-	1	2	4	5	1	2
2) Masters	2	-	-	3	2	-	-	2	4	2	1	-
3) Ph.D	4	5	1	-	4	5	1	-	2	0	1	-
IRELAND												
1) Bachelor	6	-	-	-	5	-	-	-	-	-	-	-
2) Masters	-	-	-	-	-	-	-	-	-	-	-	-
3) Ph.D	-	-	-	-	-	-	-	-	-	-	-	-
AUSTRALIA												
1) Bachelor	-	-	-	2	-	-	-	2	1	-	1	2
2) Masters	1	-	-	-	1	-	-	-	-	-	-	-
3) Ph.D	2	-	-	-	2	-	-	-	2	-	-	-
GERMANY												
1) Bachelor	-	1	-	1	-	-	-	1	2	-	-	-
2) Masters	-	-	-	-	-	-	-	-	1	-	-	-
3) Ph.D	3	-	-	-	2	-	-	-	2	-	-	-

Notes: 1. Columns I and II list staff by highest degree held (e.g. a Ph.D is not recorded under Bachelor as well).
2. Column III includes all degrees held (e.g. a Ph.D would also have recorded the country in which his Bachelor degree was taken).

Some 51 employees were born in countries other than those listed above, 38 employees received their secondary education elsewhere, and 29 university degrees were awarded elsewhere. These 34 other countries are Argentina, Austria, British West Indies, Burma, Ceylon, China, Czechoslovakia, Denmark, Egypt, France, Greece, Hungary, Indonesia, Italy, Japan, Kenya, Korea, Lithuania, Malaysia, Morocco, Netherlands, New Zealand, Nigeria, Norway, Pakistan, Poland, Romania, Russia, South Africa, Sweden, Switzerland, Tanganyika, Trinidad, Yugoslavia.

Appendix 10
Table 10B

AECL Professional Staff Comparing the Number of Working Years Since Graduation With the Number of Years Employed by AECL

I. CRNL - (a) Bachelors

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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29	1																				2									
28													1					1					1							
27																1		1			2	1	1							
26												1					1			1			1							
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23		1				1										1							1							
22					1								1							1	2	2								
21								1				1	1								1									
20		2									2			1	2					2										
19				1	1	1	1	1		1	1		2	2	1		1		2											
18		1	1		1	1	1		2	1		1		5	3	1		1												
17	1	4		2			2	2	2	4		1	2		2	1	1													
16				1				1	2	2	1	2		1		2														
15	1		1	1	1					1			1		1															
14								1			2	1		1																
13									1		1		1																	
12		4	1	1					1			3																		
11	1	1	1						1		4																			
10		1	1	1	4			2		1																				
9		1	2	1		1		1	1																					
8		3		2	4			1																						
7		1		2			2																							
6	1	3	1	1		1																								
5	2	1	1	3	2																									
4	2	2	1																											
3	2	2	6																											
2	2	5																												
1	14																													

Years Employed By AECL

Appendix 10

Throughout Table 10C time employed with AECL includes employment prior to the formation of AECL with the government agencies from which AECL grew. Table 10C

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

I. CRNL - (b) Master

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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4	1	1	1	1																										
3	1	1	5																											
2	2	4																												
1	8																													

Years Employed By AECL

Appendix 10

Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

I. CRNL - (c) Ph.D.

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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4	2	4	1	5																										
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1	6																													

Years Employed By AECL

Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

II. Commercial Products - (a) Bachelor

Years Worked Since Graduation \ Years Employed By AECL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years Since Graduation With the Number of Years Employed by AECL

II. Commercial Products - (b) Master

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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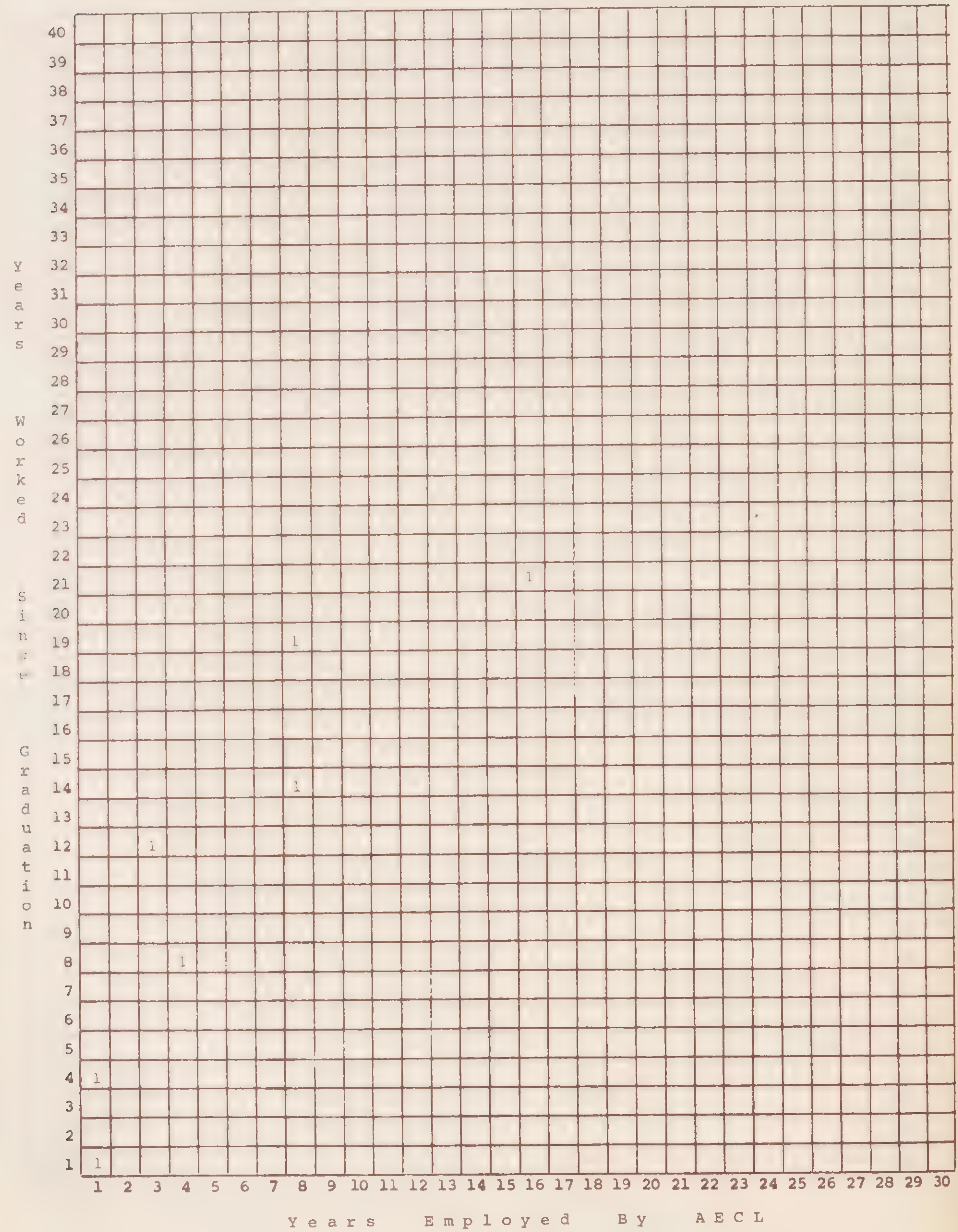
Years Employed By AECL

Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

II. Commercial Products - (c) Ph.D.



Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

III. Power Projects - (a) Bachelor

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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Years Employed By AECL

Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation With the Number of Years Employed by AECL

III. Power Projects - (b) Masters

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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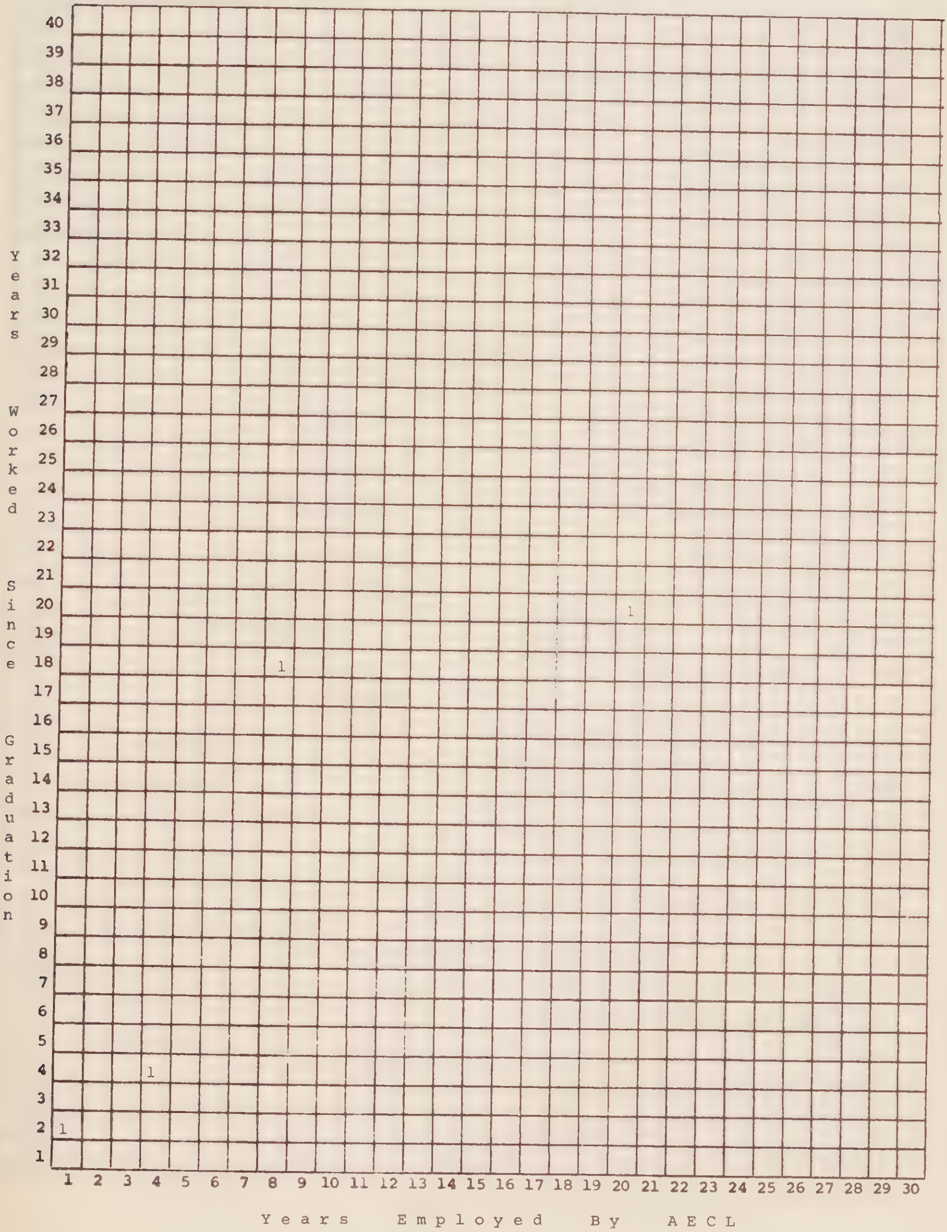
Years Employed By AECL

Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation with the Number of Years Employed by AECL

III. Power Projects - (c) Ph.D.



Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation with the Number of Years Employed by AECL

IV. WNRE - (a) Bachelor

Years Worked Since Graduation (rows) / Years Employed By AECL (columns)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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5	1				3																									
4	1		1																											
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Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation with the Number of Years Employed by AECL

IV. WNRE - (b) Masters

Years Worked Since Graduation \ Years Employed By AECL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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Years Employed By AECL

Appendix 10
Table 10C cont.

AECL Professional Staff Comparing the Number of Working Years
Since Graduation with the Number of Years Employed by AECL

IV. WNRE - (c) Ph.D.

Years Worked Since Graduation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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Years Employed By AECL

Appendix 10
Table 10C cont.

AVERAGE AGE OF AECL PROFESSIONAL STAFF BY HIGHEST DEGREE

	Bachelor	Master	Ph.D
CRNL	37	32	40
WNRE	36	30	34
CP	35	38	39
PP	37	36	37

Table 10D

PERCENTAGE OF AECL PROFESSIONAL STAFF ABLE TO OPERATE EFFECTIVELY IN CANADA'S TWO OFFICIAL LANGUAGES

	Bachelor	Master	Ph.D
CRNL	4.7%	4.5%	6.4%
WNRE	5.3%	11.7%	5.2%
CP	17.0%	5.0%	14.0%
PP	3.4%	-	-

Appendix 10
Table 10E

NUMBER OF AECL PROFESSIONAL STAFF IN EACH DEGREE CATEGORY 1962-68
WITH PROJECTIONS FOR 1969-1973

YEAR	BACHELOR				MASTER				PH.D			
	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP
1962	257	18	6	56	54	1	2	10	103	4	3	2
1963	246	41	6	61	55	3	2	15	100	9	3	2
1964	247	50	13	49	50	4	2	20	134	13	3	2
1965	260	57	25	40	52	8	5	20	118	20	4	2
1966	240	60	24	59	58	13	6	33	117	25	5	4
1967	242	69	26	55	60	16	8	32	133	33	6	4
1968	259	75	32	59	67	17	10	29	140	38	7	4
1969	282	83	33	60	71	21	11	30	146	54.	9	4
1970	279	98	35	60	71	24	12	31	146	63	11	5
1971	284	104	37	60	72	26	13	31	148	67	14	5
1972	287	112	37	60	72	28	13	31	148	72	14	5
1973	287	119	37	60	73	30	13	31	148	76	14	5

Appendix 10
Table 10F

PERCENTAGE TURNOVER OF AECL PROFESSIONAL STAFF IN EACH DEGREE CATEGORY 1962-67

YEAR	BACHELOR				MASTER				PH.D			
	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP	CRNL	WNRE	CP	PP
1962	9.3	-	27.0	9.0	3.7	-	-	2.0	4.9	-	-	-
1963	5.6	-	-	10.0	16.3	-	-	2.0	3.0	-	-	-
1964	5.6	5.6	11.0	4.0	6.0	-	-	1.0	5.9	-	6.0	-
1965	8.4	6.5	6.0	6.0	7.6	-	-	2.0	10.1	-	-	-
1966	6.6	11.7	-	2.0	8.6	-	-	1.0	7.7	3.8	-	-
1967	4.9	6.7	4.0	2.0	3.3	5.8	-	1.0	4.5	2.9	-	-

Table 10G

WORKING EXPERIENCE OF AECL PROFESSIONAL STAFF

Percentages of staff who have had outside experience before joining AECL

	CRNL	WNRE	CP	PP
(1) With Industry	44.1%	35.3%	63%	68.5%
(2) With a University	18.9%	10%	20%	4.3%
(3) With a Provincial Dept. or Agency	2.8%	4.6%	5%	6.5%
(4) With Other Federal Agencies	30.3%	23%	52%	5.4%

Appendix 10
Table 10H

EXPENDITURES

Tables 11A to 11C show AECL's expenditures over the period 1945 to 1968 and the estimates for the year 1968-69. Not included are development expenditures charged to Commercial Products costs. Table 11B shows net operating expenditures and Table 11C shows capital and non-fundable expenditures.

2. The operating and capital funds spent by AECL are shown in greater detail in Table 11D for the fiscal years 1963-64 to 1967-68 inclusive with estimates for 1968-69.

3. The operating and capital funds spent over this period by the major units at AECL sites are shown in Table 11E.

4. The expenditures associated with scientific activities over the same period are shown in Table 11F. These tables, 11D to 11F, include the development expenditures charged to Commercial Products costs.

5. Under the headings of "Functions" and the category "Intramural R & D" are included all the funds spent by AECL except those for the other functions listed. The sums indicated cover far more than the actual costs of research and development within AECL. They include major purchases of equipment that has been designed, developed and manufactured in industry under a purchase order for the supply of the end product. The figures also include payment for professional and consulting services, for materials and supplies and other non-atomic energy items such as deficits on operating hospitals and payment of grants in lieu of municipal taxes. AECL does not know of a generally accepted method of determining the costs of what could properly be called

AECL "Intramural Research and Development".

6. As regards the financial support given to professional staff towards higher education, the figures are as follows:

Cost of Education Leave to take Higher Degrees

Fiscal Year	Nos. Assisted	Total Cost
1962-63	0	$ 0
1963-64	1	1,350
1964-65	1	2,025
1965-66	2	7,825
1966-67	9	25,580
1967-68	9	35,970
1968-69	12	48,510

Payments for Credit Courses at Local Universities

Fiscal Year	Nos. Assisted	Total Cost
1962-63	-	$ -
1963-64	-	-
1964-65	-	-
1965-66	-	-
1966-67	3	118
1967-68	9	788
1968-69	14	1,362

Combining these, the totals become -

Fiscal Year	Total Funds
1962-63	$ 0
1963-64	1,350
1964-65	2,025
1965-66	7,825
1966-67	25,698
1967-68	36,758
1968-69	49,872

7. Payments for support to those who have spent "sabbatical" periods at universities or laboratories in Canada or overseas have not been included.

Appendix 11

Appendix 11
Table 11A

ATOMIC ENERGY OF CANADA LIMITED
NET OPERATING AND CAPITAL NON-FUNDABLE EXPENDITURE
FOR THE PERIOD 1945-1967
AND ESTIMATE FOR 1968

Appendix 11
Table 11B

Appendix 11
Table 11B

Appendix 11
Table 11C

APPENDIX 11
TABLE 11D

ATOMIC ENERGY OF CANADA LIMITED

OPERATING AND CAPITAL FUNDS EXPENDED BY UNITS

($000's Omitted)

	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Chalk River Nuclear Laboratories						
Science						
Physics	2,923	4,542	3,856	2,727	2,734	3,407
Biology and Health Physics	801	821	878	1,014	1,136	1,257
Chemistry and Materials	1,284	1,203	1,315	1,583	1,768	1,899
Applied Research and Development						
Applied Physics	1,737	1,769	2,020	3,060	2,500	2,526
Advanced Projects & Reactor Physics	4,466	4,518	4,726	5,588	5,467	6,341
Fuels and Materials	4,436	4,412	5,397	6,117	5,916	6,030
Plant Engineering						
Plant Design and Engineering	784	869	1,016	1,270	1,890	2,155
Operation of Research Facilities	3,595	5,083	4,885	5,381	5,669	6,063
Other Plant Services	5,940	6,387	6,818	7,179	8,416	8,451
Administration						
Administration, Finance & Medical Services	4,719	5,213	5,585	5,439	5,663	6,477
Less revenues	(2,133)	(3,034)	(2,977)	(2,884)	(2,816)	(2,450)
Total - CRNL	28,552	31,783	33,519	36,474	38,343	42,156
Whiteshell Nuclear Research Establishment						
Research & Development	1,002	2,425	3,050	4,087	6,221	6,263
Engineering Services	7,558	8,225	4,146	3,679	5,564	4,604
Medical	610	750	881	811	940	1,296
Administration & Finance	3,209	3,551	3,667	5,843	4,062	5,414
Less revenues	(103)	(352)	(537)	(652)	(820)	(934)
Total - WNRE	12,276	14,599	11,207	13,768	15,967	16,643
Power Projects						
Research & Development	1,480	1,967	3,860	2,369	3,235	3,447
Design Services	1,482	1,754	3,919	6,354	8,318	8,480
Prototype Nuclear Stations	1,229	1,461	1,556	613	4,065	820
Project Supporting Services	248	230	560	910	1,276	1,378
Administration & Finance	326	493	1,153	3,560	3,059	3,150
Less revenues	(7)	(208)	(2,374)	(3,927)	(7,117)	(9,836)
Total - Power Projects	4,758	5,697	8,674	9,879	12,836	7,439
Commercial Products						
Research & Development	612	892	1,394	1,838	2,538	3,132
Head Office						
Administration & Finance	91	100	143	628	742	1,262
TOTAL - AECL	46,289	53,071	54,937	62,587	70,426	70,632

APPENDIX 11
TABLE 11E

ATOMIC ENERGY OF CANADA LIMITED

OPERATING AND CAPITAL FUNDS EXPENDED

For the Fiscal Years 1963-64 to 1967-68 Inclusive
and Estimates for 1968-69

($000's Omitted)

	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Source of Funds						
Parliamentary appropriation	44,924	45,158	52,666	57,983	66,500	68,600
Retained earnings	753	7,021	1,277	3,612	3,004	1,000
Commercial operations R & D	612	892	994	992	922	1,032
TOTAL	46,289	53,071	54,937	62,587	70,426	70,632
Expenditures						
Operating funds	32,070	35,744	40,683	48,682	57,805	59,452
Capital funds	14,219	17,327	14,254	13,905	12,621	11,180
TOTAL	46,289	53,071	54,937	62,587	70,426	70,632
Expenditures by Sites						
Chalk River Nuclear Laboratories	28,552	31,783	33,519	36,474	38,343	42,156
Whiteshell Nuclear Research Establishment	12,276	14,599	11,207	13,768	15,967	16,643
Power Projects - Sheridan Park	4,758	5,697	8,674	9,879	12,836	7,439
Commercial Products - Ottawa	612	892	1,394	1,838	2,538	3,132
Head Office - Ottawa	91	100	143	628	742	1,262
TOTAL	46,289	53,071	54,937	62,587	70,426	70,632

APPENDIX 11
TABLE 11F

ATOMIC ENERGY OF CANADA LIMITED

EXPENDITURES ASSOCIATED WITH SCIENTIFIC ACTIVITIES

($000's Omitted)

	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Functions						
Intramural R & D (see App.11, para.5)	40,787	47,053	47,865	53,475	61,781	60,920
Data Collection	305	310	345	556	584	627
Scientific Information	601	842	953	1,291	1,513	2,365
Contracted R & D in Industry	4,496	4,732	5,593	6,792	5,839	5,876
Contracted R & D in Universities	99	132	173	447	672	794
Support of Higher Education	1	2	8	26	37	50
Total	46,289	53,071	54,937	62,587	70,426	70,632
Scientific Discipline						
Engineering and Technology	37,788	41,821	41,990	49,308	56,869	55,691
Natural Sciences						
Biological Sciences	1,725	2,300	2,686	2,662	3,031	3,196
Chemistry	2,577	3,592	4,171	4,868	4,677	5,334
Physics	4,199	5,358	6,090	5,749	5,849	6,411
Total	46,289	53,071	54,937	62,587	70,426	70,632
Areas of Application						
Nuclear Energy	46,289	53,071	54,937	62,587	70,426	70,632

RESEARCH POLICIES

Other federal agencies do not play a significant role in initiating individual AECL projects though there is considerable liaison at the scientific worker level.

2. The key to the choice of pertinent research projects is and will undoubtedly remain competent scientific and technical judgment. Formalized computer-based schemes can sort data and have a definite place as an aid in decision making, but their use is limited and technical directors must recognize and resist the temptation of allowing a computer to make the final decision.

3. A project that will solve several problems is more apt to be chosen than a narrowly oriented one. For example, the first development of a new zirconium alloy was for its use in one type of nuclear reactor, but the real spur for its development is its potential use in advanced reactors.

4. Projects are proposed from all levels. The relative value of the completed project, the competence of the staff available, and the enthusiasm that the project arouses all play a part in the decision making process.

5. In the fundamental research field a new proposal usually starts with a scientist at the working level and discussion follows with his branch head and division director. Approval is given on the merits of the proposal and at the appropriate level of financial authority. Major projects, particularly those involving capital construction, require detailed planning in advance and inclusion as specific items in annual estimates. Funds for small projects are

provided from the general operating budget and changes in detail can be made at short notice. In this way, vitality is maintained and administrative delays are kept to a minimum.

6. The majority of AECL's effort is on applied research and development projects associated with the economics and implementation of nuclear power programmes. After successful initial stages, the situation becomes more complex. As soon as a new idea has been developed to where an economic assessment of its impact and benefit for nuclear power reactors can be made, it is carefully evaluated. If the conclusions are favorable, work will continue and this often leads to in-reactor experiments. If these prove satisfactory, a more detailed economic assessment will follow. This detailed assessment must give due regard to the availability of manpower, equipment and funds and usually there must also be some meshing with related problems and projects before the project is undertaken.

7. Another type of project in the nuclear power field arises from the operation of existing nuclear reactors. Experience may point out operating problems and improvements that require the initiation of development projects.

8. A third type of applied project arises from requirements to supply specific data and test results on components of nuclear reactors that are under construction. Examples in this category are confirmation of lattice designs, fuel development and testing, and the development of control mechanisms and systems.

9. It will be seen that since most of AECL's projects are mission oriented, general priorities will be self-evident to the

professional staff working on them. In an overall nuclear power programme, most projects are not independent of each other, but interlock. This sets their relative time scales. Priorities are expressed by completion dates for phases of the project and, in many cases, must be closely scheduled to ensure that the required in-reactor irradiation facility is available at the right time and for the length of time required to meet completion dates. This chain of events often extends over a number of years.

10. In addition to timing, priorities are expressed and implemented by periodic reference to the economic benefit expected to be achieved, the likelihood of success before key application dates, and the effort required for achievement.

11. Network methods are in common use in AECL, particularly for engineering type projects involving the construction of complicated and extensive facilities where they play a vital role. These methods are used to control the engineering development, design and construction of nuclear power stations as well as for major components e. g., for the Gentilly nuclear power station now under construction and for the development, design and construction of its fuel channels and fuelling machine.

12. Network methods are also essential for commissioning new nuclear reactors and have proved invaluable for maintaining, repairing and making improvements to operating nuclear reactors. These methods are being used in the conversion that is now under way of the NPD nuclear reactor from pressurized to boiling heavy water coolant. Maintenance operations on the NRX and NRU reactors which inevitably involve changes in major experimental

equipment are examples of routine usage.

13. Many of AECL's development projects require contributions from a number of separate teams and also the construction of large and complex experimental equipment. Critical path networks have proved to be very valuable in these projects. A continuing example would be the construction and operation of engineering test loops. Current examples are the design, construction and commissioning of an experimental plant for evaluating a hydrogen-amine exchange process for heavy water production; and the development, design and construction of prototype quadrupole magnets of a new type.

14. For more basic projects, the principles of network methods are applied, but because of the nature of the input, the output is less definitive.

15. As regards contracting out projects in support of intra-mural programmes, it has been pointed out earlier that all work contracted out by AECL is in support of AECL projects. Reference has already been made to the research contracts placed in Canadian universities. Typical examples during the 1967 period were:

High Energy Fragmentation	physics	McGill
Separation of Hydrogen Isotopes	chemistry	Ottawa
Creep in Zirconium	metallurgy	UBC
Hydrogen Exchange Studies	chemical eng.	Alberta
R. F. Systems	elect. eng.	Manitoba and Ecole Polytechnique
Flows in Rod Bundles	mech. eng.	Windsor

Appendix 12

Douglas Point Effluent Studies	pollution	Toronto
Irradiation of Meats, Fruits	isotope utilization	Laval

Isotope utilization is the fastest growing sector of AECL research contracts placed with universities.

16. Applied research may also be contracted to industrial firms, for example, the development for production of large lithium drifted germanium diodes at RCA Victor and at the Ontario Research Foundation.

17. In engineering development, projects and phases of projects have been contracted out to Canadian industry, as a matter of policy, whenever AECL's special facilities are not required to do the work, when a company has some special expertise, when the company is interested in building up a development program as a long range policy or when a product is likely to develop soon. For continuing development contracts the company's effort must be of a sufficient size to be viable. In 1967-68 about 40 companies received 106 contracts.

18. For many years the largest sector has been fuel development at CGE and Canadian Westinghouse. The next largest sector would be mechanical development of reactor components - fuel channels, fuelling machines, instrumentation and materials. Another important sector would be mechanical engineering development in heat transfer and fluid flow. The contractors currently receiving the most work are CGE, Canadian Westinghouse, Orenda, Bristol Aerospace, Eldorado Nuclear Limited, and Dilworth, Secord, Meagher and Associates.

Appendix 12

19. The contracting out of all phases of prototype construction jobs (including design) which have a high content of advanced nuclear technology is also a policy of AECL, as this is probably the best way of training industry and building up capability in atomic energy. Examples during the past five years are in- and out-reactor engineering test loops, NPD fuelling machines and NPD conversion to boiling coolant. WR-1 reactor was also handled in this way but with these larger installations, the contractor would also carry out his own development programmes.

20. The construction of very large prototype power reactors such as at Douglas Point and Gentilly is handled differently as these require effort from a number of groups. Here AECL Power Projects provide the core of the design and development teams and overall project supervision. The Gentilly station is a current example of one scheme where a substantial fraction of detailed design and component development has been assigned to Canadian industry and consultants. Companies undertaking phases of the project are listed below.

Canadian Westinghouse Company Limited	Heat-transfer and fluid-flow studies; fuel-channel and fuel design and development.

Appendix 12

Canadian General Electric Company	Analytical studies; fuel-channel and fuel design and development.
Dilworth, Secord, Meagher and Associates Limited	Analytical studies; fuel handling system design and development; shut-off rod design and development.
Orenda Engines Limited	Booster-rod design; fuel channel design and development.
Dominion Bridge Company Limited	Development of welding procedures for calandria vessel.
LaSalle Hydraulic Laboratory Limited	Hydraulic model tests of moderator system.
The Shawinigan Engineering Company Limited	Analytical studies; moderator system design.
DCF Systems Limited	Analytical studies.
Computing Services Limited	Computer services.
Electronic Systems Engineering Limited	Computer application to control systems
Surveyer, Nenninger & Chênevert Incorporated with Montreal Engineering Co. Ltd.	All conventional design engineering.
Hydro Quebec	Construction at site.

21. In the case of university contracts, the annual expenditures per contract usually range from a few thousand

dollars up to $26,000. For industrial contracts AECL has found the most efficient method is to spend a minimum of $100,000 per year and preferably $200,000 with one company on one type of work. It is only in this way that a really live and productive team can be developed in the contractor's establishment. To the extent that budget limitations allow, there are advantages in having more than one contractor involved, particularly if a production run of components is the desired end.

22. For both research contracts with universities and with industry the funding is provided from the budgets of the AECL divisions requiring the work to be done, and the divisions are also responsible for technical supervision of the contracts.

23. In the arranging of a university contract, an outline of the work to be undertaken is agreed upon between the AECL supervisor and the university faculty member concerned. The estimates of the costs of direct salaries, materials and supplies, equipment, travel and clerical support are agreed. To ensure that there is no conflict with grants in aid of research provided by the National Research Council, the AECL proposal for a research contract is sent to NRC for review and comment. The formal contract is entered into between AECL and the university.

24. The distinctions between AECL contracts and the grants in aid of research of other federal agencies are that AECL requires an answer to a problem in a finite time, a member of AECL staff works closely with the university researcher and AECL retains ownership of the results of the work including any patents that arise.

25. R&D contracts with industry are handled by purchase

orders and NRC is not consulted. Costs are based on hourly rates per man to cover salaries and fringe benefits, on materials, supplies and equipment and on overhead. AECL retains ownership of all work done, but the company carrying out the contract has the right to use any designs, drawings, patents or know-how for its own purposes. AECL retains the right at its discretion to give the results to any other firm.

26. While the level of industrial development contracts from any AECL division may vary widely over the course of time, AECL attempts to smooth out the overall financial effect of its contracts on firms that have a large fraction of their staff working on AECL projects.

27. It will be seen that as extramural work from AECL is always some part of an internal project, the financing and the results are treated in the same way. We believe these arrangements result in the maximum effectiveness in the rate of learning and of reaching results at a reasonable price and within a reasonable time scale without giving any outside organization a monopoly position. These methods are in accordance with the AECL policy of fostering the maximum growth of atomic energy research and technology.

28. The continual review and planning processes which have already been described allow priorities to be determined and, based on these, available resources have to be distributed by senior management. The review processes are also designed to eliminate as much as possible any sudden need to terminate a project which has already advanced beyond the initial study stages.

Appendix 12

In AECL, professional staff often have interests and responsibilities in several projects at once and this allows for the shifting of effort quickly. On occasion a major project has to be terminated either because of lack of funding or because an alternative project has been assessed as having higher priority. The professional staff involved are kept fully informed of the decision making process and once they recognize the need for a switch, they are the first to want to move swiftly to the new project.

29. When there are several independent projects, as is the case within Commercial Products, the decision making process is different from that in the nuclear power field, where applied research and development projects are all aimed at improving nuclear power stations.

30. The shifting of research resources in funadamental long term projects tends to be done more slowly. Here changes are made by increasing or decreasing expenditures on major items of equipment and facilities, and also by moving staff with interests in the new project to strengthen the group working on it. The use of visiting experts, post doctoral fellows and attached staff facilitates the launching of a new project.

31. If an entirely new project is to be started, the major difficulty is to attract the one or two key research workers required to make a beginning.

32. With AECL's method of research contracts with universities and industry, there is no difficulty in terminating

a project within a reasonable period and of switching to a new project if this is considered desirable.

33. The efficient transfer of research results to industry is extremely difficult and presents a continuing challenge. While AECL can work well on a co-operative basis with industrial teams having long experience in nuclear technology, with other firms the AECL technical expert is often cast in the role of an unappreciated teacher who insists on advanced technological standards not normal in commercial practice.

34. AECL's output of scientific and technical publications is reported on in Appendix 13. Much of the work is available in the open literature. Reports on work considered to have commercial value is classified as "AECL Proprietary" but these are made available routinely to interested Canadian firms provided they agree not to transfer them to other organizations, including parent or affiliated firms in other countries. To act independently on the information contained in these reports, a firm must have some background knowledge of the subject and also workshop know-how. As has been mentioned, one of the best ways of acquiring this is to attach engineering staff to an AECL establishment. At present there are 23 such attached staff at CRNL, 10 at Power Projects and four at WNRE. Transfers of research results to Ontario Hydro and Hydro-Quebec are in a different category since AECL has major co-operative projects with these utilities. They have a large number of engineers attached to AECL. Many are specialists in fields unfamiliar to AECL and others are attached primarily for training purposes.

Appendix 12

35. AECL has found it most useful to organize conferences and meetings where Canadian industry, other government agencies and universities can be informed of and comment on the Company's plans. AECL has held, for example, 12 symposia on atomic power which have been attended by a wide cross-section of Canadian industry.

36. Government agencies and university staff have ready access to AECL reports and lists of these reports are widely available. The latest information flows freely between specialists if there is common interest or a collaborative programme.

37. As a general principle, it is recognized that research results are most efficiently trnsferred by people rather than by documents. The interest raised by a discussion can be followed by the reading of reports.

38. As regards contracted extramural results, they are treated by AECL in the same way as results obtained from intramural research. Interim technical memoranda are required by AECL as the work progresses to avoid the delays of formal documentation. Formal progress reports are submitted periodically and a final report is required on the completion of the work.

Appendix 12

RESEARCH OUTPUT

AECL files patent applications in Canada and in a number of foreign countries on an average of over 20 new inventions per year. In addition to patents arising from its own work, it owns the Canadian rights to several hundred Canadian patents arising from early U. K. -U. S. -Canada collaboration. Current agreements for collaboration with the U. S. Atomic Energy Commission involve reciprocal patent rights on inventions related to heavy water nuclear reactors.

2. The two most important areas for exploitation are inventions related to nuclear power reactors and those related to the application of isotopes. Up to the present, AECL has made available to Canadian industry, on a royalty free basis, rights to use AECL patents in the nuclear power field, and no formal licencing has been necessary. The reasons for this policy are that AECL has been the main customer for work done using the inventions, and because any U. S. competitor to a Canadian firm could obtain a royalty free licence from the USAEC. It is USAEC policy to make available to U. S. industry licences on a royalty free basis.

3. In commercial arrangements with other countries on nuclear reactor design and know-how, AECL patents have been included as part of the contract terms. The value of the patents themselves is considered to be of less importance than that of AECL know-how. No revenue figures can therefore be given on the patents taken out by AECL in the nuclear power field. However the UKAEA paid AECL $750,000 for AECL patents and know-how to balance an exchange of information in both directions.

Appendix 13

4. Patents have, of course, a hidden value in that they prevent others obtaining patents and then requiring payment for the use of them by AECL and Canadian industry. If a patent is of marginal value, the invention is often published instead, thereby preventing the issuance of a patent by another organization.

5. In the area of isotope application, the patents obtained by Commercial Products are exploited by CP itself through the manufacture and sale of products or by commercial licencing agreements to manufacture a product rather than the licencing of a patent itself.

Thus, conventional licencing by AECL through Canadian Patents and Development Limited is only considered for patents relating to a small part of AECL's activities, generally in the instrumentation field. Even in this narrow sphere, the success of licencing is not a proper measure of the research output being exploited by Canadian industry. For example, in the period under consideration, CRNL developed an ion chamber for monitoring neutrons from cosmic rays. The design and know-how were transferred to a Toronto firm who manufactured, in addition to requirements in Canada, about $700,000 worth for the export market. There is no patent.

6. The statistical data on AECL patents is as follows:

	1962	1963	1964	1965	1966	1967
Reactor & Misc. Applications - initial filings	8	11	21	24	34	18
Commercial Products Applications - initial filings	0	5	4	5	0	10

7. One licence was issued in this period resulting in $5,356 in royalties, and business generated in Canada of $153,000. Licence fees from earlier patents, totalling a few thousand dollars, would also be received during this period.

Appendix 13

8. Books and papers arising from the research activities of AECL are published through the normal channels. Contributions are made to journals published both in Canada and other countries. The number of publications is given in Table 13A. All of these publications are listed in an AECL List of Publications which is produced annually with a cumulative issue at intervals, and this list is widely distributed (290 copies in Canada and 860 outside Canada) - particularly to technical libraries and to universities throughout Canada.

9. Abstracts of all AECL publications are supplied to the USAEC for publication in Nuclear Science Abstracts. AECL also sends abstracts of all other Canadian publications in the nuclear science field to Nuclear Science Abstracts, thus ensuring that they are widely announced. The total number of abstracts collected in a year by NSA is about 47,000. In 1967 the contribution of those published in Canada was 309, of which 132 came from AECL. AECL also had some 165 papers in journals published in other countries.

10. All completed research projects that are not reported by the publications previously mentioned are recorded in reports in the AECL-series. These are published by an initial distribution to depository libraries and others in Canada (28 copies) and throughout the world (212 copies). They are also announced, as in the case of papers, in the AECL List of Publications and in Nuclear Science Abstracts.

11. In addition, large numbers of reports are prepared which although unpublished, i. e., not available to the general public, are issued to Canadian industrial companies with an interest in the nuclear science field, to the science departments of Canadian universities, and to other government departments.

12. The majority of these unpublished reports are listed in a monthly announcement list which is issued to the organizations concerned.

13. The numbers of both published and unpublished reports produced during the past six years are given in Table 13A.

The principal method of transferring the results of programmes and projects is by papers and reports discussed in the preceding paragraphs. In addition, considerable use is made of participation in conferences. AECL organizes a conference at approximately yearly intervals known as the "AECL Power Symposium" at which a number of presentations by senior staff are made reviewing in some detail the current status of research and development directed toward the nuclear generation of power. Invitations to participate in this symposium are issued to a large number of Canadian companies and utilities, to government departments, and to other people who may be interested.

14. Substantial contributions are made to the annual conferences of the Canadian Nuclear Association and the American Nuclear Society. A number of symposia on specific research topics are organized by AECL sites and participation is invited from interested parties. AECL is a major participant in symposia and panels organized by the International Atomic Energy Agency. It also contributed many notable papers to the three United Nations Conferences on the Peaceful Uses of Atomic Energy, the last of which was held in 1964. The staff of AECL are encouraged to contribute to conferences organized by other scientific, technical and international bodies in Canada and elsewhere. The extent of active contribution is indicated by the following figures:

Presentations at Conferences by AECL Staff

	Year					
	1962	1963	1964	1965	1966	1967
Number of Papers Presented:	155	175	139	191	211	219

15. AECL collects considerable numbers of scientific and technical documents as a result of exchange agreements with other countries that have significant activities in the nuclear science field. The following figures give the quantities received in recent years:

Technical Reports Received from Other Countries

	Year					
	1962	1963	1964	1965	1966	1967
Published Reports:	10,845	11,790	11,247	11,430	11,492	12,510
Unpublished Reports:	350	237	620	527	233	649

16. The documents so received are initially stored in the library at Chalk River Nuclear Laboratories which is recognized as the major depository in Canada for the literature of nuclear science. This library announces receipt of the published documents in a Weekly Accessions List which is circulated to many scientific libraries and industries in Canada and the documents are offered for loan or by photocopy.

17. The transfer of the unpublished reports received from other countries is limited by the conditions placed on distribution by their originators. However, about 90 per cent of them are announced and made available for loan to a number of Canadian industrial companies with interest in the nuclear science field.

18. Since AECL considers one of its functions is to train people to promote and expand nuclear science and technology throughout Canada,

people who receive specialized training with AECL and then leave to apply their experience elsewhere in Canada are regarded as an important "product."

19. The following table lists the number of such people who have left AECL in the past six years. It does not include those who have gone outside Canada or those who work in fields in which their AECL training is of little relevance.

20. Also, those having AECL training periods of two years or less have been omitted. Many of the people in this category will be young scientists and engineers who leave either to take advanced degrees or to become reactor operations engineers with utilities. In both cases AECL training nevertheless is of real value to them. Another significant group in this category are engineers from Canadian industry attached to AECL, primarily for training.

Number of Staff From AECL

	1962	1963	1964	1965	1966	1967
To industry, in atomic energy (includes utilities)	4	9	2	5	2	3
To universities, doing research related to atomic energy	4	3	2	4	9	3
To other, using specialized AECL knowledge (laboratories, other government agencies)	2	1	3	7	4	5

21. The following teams have been very active and successful in the period 1962-67 and are recognized as world authorities in their fields. The work of a team will cover a number of years, with no one year being particularly significant.

(a) Biology & Health Physics

- For the study of human population genetics - attempts to assess possible radiation effects have led to statistical surveys of large populations.

- For the study of dispersal of radionuclides in the environment - the atmosphere, ground and water.
- For the study of radiation dosimetry.

(b) Physics

- For precise study and (low energy physics) measurements of the properties of heavier atomic nuclei, using tandem Van de Graaff accelerators with advanced detectors and on-line computing equipment.
- For the study of lattice vibrations, electron orbits and other aspects of nuclear structure and solid state physics using the inelastic scattering of neutrons.
- For the study of nuclear structure using high resolution beta ray spectrometry.
- For the study of the physics of fission.
- For the study of neutrons from cosmic rays -- from monitoring stations in North America and elsewhere.

(c) Chemistry

- For the study of penetration and channelling effects on solids of bombarding particles.
- For the study of the water chemistry of reactor coolants.
- For the study of radiation effects on organic coolants for reactors.
- For the study of radiation dosimetry.

(d) Materials Science

- For the study of diffusion in metals and radiation effects.
- For the study of the action of UO_2 and of other fuels under irradiation.

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- For the study of reactor materials under irradiation - creep, tensile properties, corrosion.
- For the study of radiation damage effects using electron microscopy.
- For the study of new materials and alloys which may be suitable for use in reactors.

(e) General

- For the development of in-reactor engineering test loops for irradiating experimental fuel and for developing new reactor concepts.
- For the study of heat transfer and hydrodynamics related to reactor coolants and fuel channels.
- For the development, including measurement, of basic nuclear data required for the design of heavy water reactors. This includes measurements (using six reactors) of fission cross-sections of fresh and long-irradiated fuels, of reactivities of fuel lattice designs, of scattering of neutrons by reactor moderators and fuels, of absorption of neutrons by reactor materials.
- For the development of low neutron capture materials and methods of operation for an organic cooled, D_2O moderated reactor.
- For the exploitation of large volume lithium-drift germanium detectors for experiments in nuclear and neutron physics, reactor physics, activation analysis.
- For the development of reactor components. This heading includes a number of unique government - industry teams

evolving advanced designs as follows:

- fuel and fuel fabrication.
- fuel channels.
- fuelling machines.
- pump and other types of seals.
- control systems.
- D_2O containment systems.

(f) Commercial Products

- The Research Division in Commercial Products has a broad diversity of specialists. It has been observed on many occasions, in the radioisotope and radioisotope equipment sales field, that AECL-CP is the only organization in the world that offers a complete service of isotopes, equipment and technical support. The CP Research Division supplies an important element of that capability.
- More specifically within the Research Division there is a team whose special interests are industrial radioisotope applications.
- In the field of food irradiation, the in-house staff is one of the most knowledgeable on the subject, and together with the team of research workers being built up in Canadian universities under contract, comprises a world known capability.
- A third group concerned with the development of energy sources, using the energy of radioactive decay, is still much of an embryo.

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22. A complete list of the unique or valuable research tools, facilities or processes added to, or developed by, AECL during the period 1962-67 would be extremely lengthy, but the following listing includes the major items. They are listed for convenience in the order of nuclear reactors, testing facilities added to research reactors, nuclear reactor development, and other fields.

(a) Nuclear Reactors

- The Douglas Point nuclear power station, Canada's first commercial sized nuclear power plant, with a net output of 200,000 kilowatts of electricity, went into operation.
- Detailed studies showed that a nuclear power reactor using natural uranium fuel and heavy water moderator, but with boiling light water as the heat transfer fluid, was feasible both technically and economically. Detailed design, development and construction of a prototype BLW nuclear power station (at Gentilly, Que.) to produce a net electrical output of 250,000 kilowatts is well under way.
- A nuclear research reactor, WR-1, an organic cooled version of the CANDU reactor system, was built and brought into operation at WNRE. It was built to prove the organic cooled concept, namely the operation of a high temperature, low pressure system using a radiation resistant oil as the heat transport fluid. After successfully demonstrating the feasibility of the concept, it is now used as a materials testing reactor in a programme aimed at increasing the operating temperature and hence the efficiency of nuclear power reactors. It is particularly suited to this role because it allows experiments to be carried out at liquid coolant

temperatures significantly higher than those available in most test reactors in North America.

- After NPD (Canada's first nuclear power station) had demonstrated the feasibility and reliability of CANDU-type nuclear power stations, it became partly available for experiments, chiefly on nuclear fuel. At present it is being converted from a pressurized to a boiling heavy water coolant system.

(b) Testing Facilities added to Research Reactors

- For the NRX reactor at CRNL a new engineering test loop was added to study the chemistry of water systems and an existing loop was converted from superheated steam to fog coolant. In-reactor creep test machines were also developed and installed.
- In the NRU reactor, three new engineering test loops were installed, one for organic coolant, another for hydraulic test and another as a new advanced water systems loop which can use either boiling water, steam or fog coolant. The reactor was modified so that a different fuel could be used thereby making more test sites in the reactor available for experiments and irradiations.
- A computer was installed for the development of reactor control by means of a computer; creep test machines were installed as well as a triple axis neutron spectrometer.
- At WNRE, nine out-reactor loops have been made to allow testing to take place under simulated non-radioactive conditions; three in-reactor loops are under construction to allow testing under actual reactor conditions.

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(c) Nuclear Reactor Development

- Hot cells for the remote examination of irradiated fuels and other radioactive materials have been built at WNRE.
- In-line instrumentation for continuous monitoring of reactor coolant under process conditions has been developed. This could find many applications in the chemical industry and elsewhere.
- A component development laboratory at Power Projects has been brought into service.
- At WNRE a process has been developed to control the water content of the organic coolant.
- Greatly improved plants for the upgrading of heavy water have been built.

(d) Other fields

- The Whiteshell research and development laboratories became fully operational.
- Cosmic ray neutron monitors were developed for use during the International Quiet Sun Year and found continuing world-wide acceptance. Three monitoring stations were installed in northern Canada.
- A 10 MV MP Tandem Van de Graaff accelerator was installed and brought into operation for nuclear physics experiments. It replaced the former EN Tandem accelerator that was moved to the University of Montreal. Pioneering work on these machines with on-line data processing and experiment control by computer was successful. The MP Tandem is operated on three eight-hour shifts, five days per week.

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- A 2 MV Van de Graaff accelerator was installed to augment work with an electromagnetic mass separator to study channelling effects in crystals from ion bombardment.
- The CRNL computation centre added a CDC 3100 satellite computer to the existing Bendix G20 Model.
- Lithium drifted germanium detectors with very high resolution were developed and the processes extended to produce very large volume detectors for increased sensitivity.
- At CRNL the Perch Lake drainage basin was adapted for use in collaboration with other agencies to determine water and energy budgets by isotopic measurements.

(e) At Commercial Products the following facilities have been built:

(i) A mobile laboratory which permits laboratory facilities to be taken directly to the site for application of radioisotopes on industrial problems.

(ii) A Mobile Irradiator, a medium-sized demonstration gamma irradiator, which can be taken to any site for the gamma-ray processing of various materials to demonstrate or test for various effects.

(iii) An experimental facility for handling a variety of gamma-ray sources and consisting of a deep, specially designed, water pool with a heavily shielded working area above it.

(iv) Specialized neutron activation systems for elemental analysis and tracer isotope production, based on the neutrons available from the reaction of antimony gamma rays on a beryllium block.

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(iv) Specialized large gamma radiation irradiators, both as laboratory devices for relatively small samples and large ones for pilot scale tests.

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23. The impact of AECL's scientific activities and research output on the advancement of scientific knowledge and Canadian economic development can be best considered under three headings -- Nuclear Power Programme, Isotope Programme and Basic Research.

Nuclear Power Programme

24. The present nuclear power programme in Canada, the future plans of Ontario Hydro and the Canadian-designed nuclear power stations under construction in India and Pakistan are some of the concrete examples of the impact of AECL's activities. In a wider circle, there are two nuclear fuel manufacturers that have been established in Canadian industry, and two 400-ton-per-annum heavy water plants under construction in Nova Scotia by Canadian firms pursuant to agreements with AECL to underwrite the sale of the heavy water produced. A zirconium alloy industry is being established in Canada. Scores of firms have been involved in making special products with new techniques.

25. In less than 15 years know-how in the nuclear power field in Canada has grown from practically zero to where there are now design organizations with some 2,000 professional man-years of nuclear boiler-plant experience; construction teams with 300 professional and technical man-years of nuclear plant experience, and operational organizations with 1,000 man-years of professional experience. These are but three of many examples that could be given to illustrate the extent to which the nuclear power programme generated by AECL has produced in Canada a considerable and expanding competence in

nuclear technology.

Isotopes Programme

26. The existence of AECL-Commercial Products' line of products, including beam therapy units, irradiators and other equipment, and their commercial sales in a competitive world market is ample evidence of their impact on Canadian economic development. Their substantial earnings in a new and advanced field are of special note.

Basic Research

27. During the period 1962-67 AECL pioneered various techniques which are now used in the world scientific community. The following is a partial list:

- The use of lithium-drifted germanium detectors to measure nuclear lifetimes, in the range 10^{-11} to 10^{-14} seconds, by gamma-ray Doppler shift measurements.
- Very sensitive neutron detection systems for continuously monitoring the cosmic-ray neutron intensity.
- The use of the "on-line" computer system at the Tandem accelerator for data acquisition and reduction.
- The use of inelastic neutron scattering for the study of the dynamic structure of solids and liquids. Several different types of spectrometers were devised for this study and the designs are widely used.
- The phenomena of "channelling" of charged particles in the spaces between rows of atoms in crystals now being used as a technique to investigate (a) the location of foreign atoms on an atomic scale in crystals,

(b) the lifetime of nuclear fission, (c) details on a microscopic scale of radiation damage and annealing behaviour in semi-conductors, (d) the atomic configuration of oxides on solid surfaces, and (f) for rapid orientation of single crystals.

- The use of computers in medical record linkage for detailed genetic analyses of human families.

28. Important contributions by AECL to the advancement of scientific knowledge during the years 1962-1967 include the following:

- Nuclear structure studies showed that light nuclei can be understood in terms of collective motion of the nucleons, e.g., several examples of fast electric octupole transitions were discovered corresponding to pear-shaped oscillations.
- Studies of nuclear fission in heavy elements have given significant information on its mechanism.
- Comprehensive studies of the gamma-rays arising from neutron capture in the elements are widely used in shielding calculations and nuclear structure analysis.
- Inelastic neutron scattering studies have given new understanding of interatomic forces in metals, ionic compounds, semi-conductors, ferroelectrics, magnetic materials and liquids.
- A theory of anharmonic effects in crystal vibrations and its applications to the understanding of, for example, thermal conductivity.
- Detailed studies of the penetration of charged particles into solids have demonstrated the new phenomenon called "channelling" and given further understanding of energy losses in matter.

- Studies of chemical changes in molecules absorbed on solid surfaces under the influence of radiation have given some understanding of energy transfer processes and reactions at interfaces.
- Pioneer work on the identification of ultraviolet irradiation products of purines and pyrimidines form the basis for similar work being carried out on DNA.
- The results of the study of the uptake of tritiated water and its fate in the human body are widely used.

29. The scientific work of AECL has been recognized internationally by the award of the following prizes during the years 1962-1967 inclusive:

- Atoms for Peace Award 1967	- W. B. Lewis
- American Nuclear Society Radiation Industry Award 1967	- G. T. Ewan and A. Tavendale
- Electrochemical Society T. D. Callinan Award 1967	- J. A. Davies and J. P. S. Pringle
- Physical Society (London) Duddell Memorial Medal and Prize 1963	- B. N. Brockhouse
- American Physical Society Oliver E. Buckley Prize for Solid State Physics 1962	- B. N. Brockhouse

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TABLE 13 A

Books, Papers and Reports Arising from AECL Research Activities

	1962	1963	1964	1965	1966	1967
Publications:						
Books or major contributions to books:	1	1	1	5	2	1
Papers published in journals:	116	122	138	124	131	150
Papers published in conference proceedings:	13	15	15	17	22	39
Reports, published AECL-series:	94	89	112	124	111	107
Total	224	227	266	270	266	297
Unpublished Reports:						
Technical reports:	179	178	212	306	540	627
Minutes of technical meetings:	36	17	61	94	128	106
Progress reports:	61	57	69	81	102	92
Total	276	252	342	481	770	825

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PROJECTS: 1962-67

Because of the inter-disciplinary nature of much of AECL's work, it is preferable to list the projects undertaken during the five-year period 1962-67 by sites rather than by divisional units.

Titles or other brief descriptions are given below in the order - Chalk River Nuclear Laboratories, Whiteshell Nuclear Research Establishment, Power Projects, Commercial Products. Case histories of the most significant completed projects follow the site listing of projects.

CHALK RIVER NUCLEAR LABORATORIES

The CRNL listings, for convenience, have been grouped under two separate headings - applied research and development, and basic research.

A. CRNL Applied Research and Development Projects

(An asterisk indicates that a case history has been prepared.)

A1. Reactors

A1. 1* The Whiteshell Reactor, WR-1.

A1. 2 Gentilly Nuclear Power Plant, CANDU-BLW-250.

A1. 3 Conversion of NPD cooling from pressurized heavy water to boiling heavy water.

A1. 4 Replacement for NRX core (consideration of high fast-flux facility for materials testing, etc.).

A1. 5 Advanced power reactor concepts (organic cooled high-steam-quality BLW, multiple pressures, superheat).

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A2. Fuel Development for Specific Reactors

- A2.1* Fuel for Douglas Point Reactor, CANDU-PHW-200.
- A2.2 Fuel for Pickering Reactors, CANDU-PHW-500.
- A2.3 Fuel for Gentilly Reactor, CANDU-BLW-250.
- A2.4 Fuel for research reactors NRX, NRU, WR-1.

A3. Advanced Fuel Development

- A3.1 Fuel for reactors to produce superheated steam.
- A3.2 Plutonium-containing fuel.
- A3.3 High density fuel for CANDU reactors (uranium silicide U_3Si).
- A3.4 Thorium-based fuel to use initial enrichment of U-235 with later transition to U-233.

A4. Reactor Core Components

- A4.1* Zirconium-niobium pressure tubes for power reactors.
- A4.2 Development of reactor channels for high temperatures.
- A4.3 Heavy water production - processes and sources.
- A4.4* Heavy-water up-grading.
- A4.5 Graphite reflectors displacing more expensive D_2O inside the reactor tank.

A5. Mechanical Component Development

- A5.1* Rotating shaft seals for primary coolant systems.
- A5.2 Fuel handling, fuelling machine components.
- A5.3 Industrial valve improvement programme.
- A5.4 Joining of dissimilar metals, especially for connection of pressure tubes.
- A5.5 Fuel channel closures (flap valve).

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A6. <u>In-reactor Research Equipment</u>

A6.1* In-reactor creep measuring devices:

A6.1.1 Measurement of creep properties on stressed specimens at elevated temperatures.

A6.1.2 Gauging of pressure tubes during service.

A6.2 Sensors for measuring gas pressures in operating fuel elements.

A6.3 Thermocouples for measuring temperatures of fuel and fuel cladding.

A6.4* Self-powered neutron and gamma-ray detectors.

A6.5 Irradiation facilities ("rabbits") for quick insertion and removal of fuel specimens or isotope targets.

A6.6 Fuel moving device for subjecting test fuel to many power cycles by insertion and withdrawal from the high flux region.

A7. <u>Remote Handling and Testing of Highly Radioactive Materials</u>

A7.1 Development of techniques for use in shielded "caves": metallography, electron and optical microscopy, mechanical testing, metrology, etc.

A7.2 Handling and transfer of Cobalt-60 produced in NRX and NRU.

A7.3 Measurements of fission product distribution, particularly the noble gases, in fuel elements.

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A8. Materials Technology

A8.1* Properties of fuel materials including UO_2, UC, U_3Si, impregnated graphite.

A8.2 Physical properties, corrosion, irradiation effects, and industrial fabrication of structural materials including zirconium alloys, steels, aluminum, high-nickel alloys. (c.f. also A4.1).

A8.3 Development of zirconium alloys suitable for cladding high temperature fuels.

A8.4 Chemistry of coolants and moderators:

A8.4.1 Application of mild steel to heat exchangers, feed-water heaters, etc. in pressurized heavy-water reactors.

A8.4.2 Development of boiling water chemistry control for replacing stainless steel.

A8.4.3 Chemical control for organic coolant.

A9. Physics of Reactor Cores

A9.1 Measurement in the ZED-2 reactor of macroscopic and microscopic lattice parameters for pressure tube reactors using clustered fuel.

A9.2 Nuclear data for reactor calculations:

A9.2.1 In co-operation with UKAEA, measurements at NRU to determine the law governing scattering of neutrons by various moderator materials.

A9.2.2 Measurements of differential and integral cross sections for reactor fuel and structural materials.

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A9.2.3 Compilation and evaluation of relevant cross section data and development of simplified theory for using it.

A9.3 Development of methods for calculating lattice parameters for pressure tube heavy water reactors using clustered fuel.

A9.4 Compilation of a computer code combining physics, economics and engineering data to obtain an optimum reactor design.

A9.5 Determination of optimum fuelling programme for natural uranium reactors with bi-directional, on-power refuelling.

A9.6 Measurement and development of theory to determine reactivity effects and local perturbations caused by fully enriched "booster" rods inserted in heavy water reactors.

A9.7* Measurements and development of theory to determine the change of fuel reactivity as a function of total heat output or "burnup".

A10. Heat Transfer and Fluid Dynamics

A10.1 Determination of the point of dryout in clustered reactor fuel cooled by boiling water.

A10.2* Two-phase heat transfer and the evolution of the BLW concept. Selection of boiling light water coolant as the alternative to heavy water and in preference to fog or steam cooling.

A10.3 Experimental and analytical study of flow instability in parallel channels in a boiling-water-cooled pressure tube reactor.

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A10.4 Studies of the nature and causes of fuel vibrations induced by coolant flow.

A10.5 Fundamental studies of surface wetting in fog-cooled channels.

A11. Reactor Safety Studies

A11.1 Measurement and analysis of the short (milliseconds) and long term (seconds) behaviour when the coolant is discharged from a water cooled reactor channel following an external piping rupture i.e. blowdown studies.

A11.2 Studies of the effect of introducing emergency cooling into a reactor channel.

A11.3 Pressure tube rupture:

A11.3.1 Determination of critical crack length for crack propagation.

A11.3.2 Pressure tube bursting tests in a simulated reactor lattice.

A12. Non-Destructive Testing

A12.1 Checking uniformity of fuel in special fuel rods.

A12.2 High resolution ultrasonic testing of fuel cladding integrity.

A12.3 Ultrasonic crack detector for quality control of pressure tube material.

A12.4 Eddy-current testing of physical condition of zirconium alloy tubes.

A13. Instrumentation and Control

A13.1 Reactor control and operation:

A13.1.1 Self-powered detectors (c. f. A6.4)

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A13.1.2 Special instrumentation for initial startup of reactors.

A13.1.3 Fuel defect monitors.

A13.1.4 Heavy water leak detection

A13.1.4.1 chemically impregnated tapes

A13.1.4.2 infra-red spectrometer

A13.1.5 Amplifiers, pre-amplifiers, etc.

A13.1.6 Computer processing of operational data.

A13.2 Health physics instruments:

A13.2.1 Area monitors to warn of excessive radiation or tritium.

A13.2.2 Portable radiation survey meters.

A13.2.3 Iodine detectors in reactor gaseous effluents.

A13.2.4 Hand and foot monitors.

A13.2.5 "Friskers" to detect general contamination on personnel.

A13.2.6 Urine analysers.

A13.2.7 Pocket warning dosimeters.

A13.3 Research Instruments:

A13.3.1* Germanium gamma ray spectrometers for high resolution, including associated low-noise amplifiers.

A13.3.2 Cosmic ray monitors.

A13.3.3 Computer assemblies for on-line processing of experimental data (Tandem accelerator installation, SUCCESS system, etc.)

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A14. Intense Neutron Generator Study (ING)

A14.1 Production of a continuous high current of protons in a well defined beam suitable for further acceleration.

A14.2 Study of radio frequency electromagnetic fields in structures suitable for efficient acceleration of a proton beam.

A14.3 Control and acceleration of a high current beam of protons in radiofrequency fields.

A14.4 Magnetic guidance and focussing of the proton beam with minimum loss of protons.

A14.5 Generation of radiofrequency power with high efficiency and low cost.

A14.6 Development of a liquid-lead-bismuth target for neutron production and heat removal involving problems of pumping, corrosion, and mass transfer.

CASE HISTORIES

A1.1 WR-1 REACTOR PROJECT

As a result of studies during the late 1950's of the means by which the unit capital cost of nuclear power stations might be reduced, CGE proposed replacement of heavy water by an organic fluid as the coolant for nuclear reactors. On the basis both of the potential indicated through ensuing CGE and AECL evaluations, and of the results of the American programme for development of this coolant, AECL decided to build an experimental reactor of this type as the first major facility for the Whiteshell Nuclear Research Establishment.

The project was officially authorized shortly after the negotiation in the spring of 1962 of firm prices for more than two-thirds of the $14. 5 million estimated cost. The facility was in operation before the end of 1965. The cost was within the original estimate and payments to industry peaked at very nearly $6 million during fiscal 1964-65. The project provided good experience for the CGE team in meeting expense and schedule targets and was an excellent example of achievement through the combined effort of industry and AECL.

The operation of this reactor has not only demonstrated the feasibility of an organic as a reactor coolant, but also the reactor has turned out, in the tradition of NRX and NRU, to be one of the world's foremost facilities for the development of nuclear fuels and materials.

A2. 1 DEVELOPMENT OF FUEL FOR THE DOUGLAS POINT REACTOR

The starting point for the development of a fuel bundle for the Douglas Point reactor was the bundle design developed for the earlier (and smaller) NPD reactor. The overall length of the 19-element bundle of about 50 cm and its diameter of about 8 cm were retained, but to meet the more stringent operational and economic conditions of the Douglas Point reactor, a number of less obvious but operationally important changes were required:

(a) The maximum power output from each bundle was doubled from 210 kW to 420 kW, requiring detailed changes within the elements and a large amount of testing to demonstrate the acceptability of such an increase.

(b) A large amount of endurance and wear testing was required because of a 55 per cent increase in coolant flow and a 400 per cent increase in bundle movement during fuel loading. Satisfactory fretting and wear properties for the bundle were achieved by adding special bearing pads.

(c) The system pressure in the Douglas Point reactor was to be 40 per cent greater than in NPD. Unless the thickness of the Zircaloy sheath on the elements was increased it would collapse on to the UO_2 pellets. It was decided that we should depart from current world practice and allow complete sheath collapse, stopping short only at longitudinal ridge formation. This resulted in a fuel bundle that was both cheaper to build and contained more UO_2 fuel (and was thus able to produce more energy). These changes required a considerable amount of testing to demonstrate the satisfactory performance of such fuel bundles.

(d) To reduce the fabrication cost of the fuel we developed resistance welds for sealing fuel elements. To reduce the probability of defects a high resolution ultrasonic crack detector was developed for inspecting the very thin (0.016 in. wall) Zircaloy-2 fuel sheaths.

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Each of the above changes required changed in manufacturing techniques and a large amount of both in-reactor and out-reactor testing to define the precise manufacturing process necessary for mass production. This involved a close co-operation between CRNL, the reactor designers, and the two prospective fuel fabricators - Canadian General Electric and Canadian Westinghouse.

The fuel charge for Douglas Point was the first in Canada to be built to a fixed price contract. The price was $74 per kg of uranium which allows the Douglas Point reactor to have a fuelling cost of around 1 mill per kWh. The fuel is now operating well in the Douglas Point reactor and many prototypical bundles have been successfully irradiated in NRU and in NPD at ratings well above their design value to burnups greater than the 9000 MWd/TeU expected in Douglas Point. A bundle about 20 inches long and $3\frac{1}{4}$ inches in diameter generates as much steam as 20 carloads of coal.

This development has led to the establishment of a Canadian nuclear fuel industry with estimated total domestic sales of $7 million in 1970, increasing to $23 million in 1975. Furthermore, as a result of the intensive programme of manufacturing development directed and supported by CRNL, Canadian fuel fabrication costs are the lowest in the world so that our industry is in a strong position to obtain export orders.

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A4.1 DEVELOPMENT OF ZIRCONIUM-2.5% NIOBIUM PRESSURE TUBES FOR POWER REACTOR APPLICATION

There are strong economic incentives to make pressure tubes for CANDU reactors from materials having low caputre cross-sections for thermal neutrons and to limit the amount of material introduced into the reactor core by using the strongest materials available. The most suitable material available has been Zircaloy-2, an alloy of zirconium, tin, chromium, nickel and iron with a strength of 48,000 psi at 300°C. Pressure tubes of this alloy are used in NPD and Douglas Point and will be used in the Pickering I and II reactors.

In 1959 laboratory scale studies were initiated at CRNL on an alloy of zirconium and niobium discovered by the Russians, viz, Zr-2.5% Nb, with a neutron cross-section similar to Zircaloy-2 but with a tensile strength up to 85,000 psi at 300°C, depending on its metallurgical condition. By 1961 the results of our laboratory studies had confirmed the superiority of the Zr-Nb alloy over Zircaloy-2. The next stage was for our metallurgists in collaboration with an industrial shop to establish a realistic fabrication route involving extrusion, drawing and heat treatment to produce tubes about 25 feet long with a diameter of three to four inches. Since there was no Canadian company willing and able to undertake this development a contract was placed with an American company. This stage of development was concluded in 1964 with the delivery of six tubes of production sizes but

of doubtful quality in aspects relevant to reactor usė.

The predicted high strength was confirmed in all tubes and one of the tubes was good enough for insertion into the NRX reactor for evaluation under power reactor operating conditions.

Up to this stage our efforts were concentrated on obtaining Zr-Nb pressure tubes having maximum strength, i.e., tubes in the heat treated condition. Our experience showed, however, that the heat treatment was difficult to perform, mainly because of the lack of suitable heat treatment furnaces and the difficulties in processing heat treated tubes to the specified dimensional tolerances.

In early 1964 an assessment of new laboratory data on the tensile strength of the Zr-2.5% Nb alloy in various metallurgical conditions continued to show the superiority of the heat treated material but there was sufficient evidence to encourage the development of Zr-Nb tubes in the cold worked condition provided the starting condition of the material was metallurgically controlled.

Development contracts were placed at two United States companies for the fabrication of 12 production-size pressure tubes from each company. The contracts were successfully completed in 1965-1966. One company's performance was significantly better than that of the other in terms of both delivery and overall quality of the tubes. The predicted effects of different fabrication methods on the strengths of the tubes were confirmed. The best tubes were stronger than 70,000 psi at 300°C.

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About this time the reference diameter of power reactor pressure tubes was increased from $3\frac{1}{4}$ inches to 4 inches. The company that had made the best tubes then demonstrated that 4-inch diameter tubes could be made to the same strength and meeting all other quality requirements. Selected tubes of cold worked Zr-Nb were inserted into NRU for evaluation under power reactor operating conditions, and later similar tubes were put into NPD and the United States reactor PRTR to obtain experience over a wider range of conditions; these tubes are still being measured from time to time to determine dimensional changes resulting from the operating environment.

A review of all available data on the fabrication and properties of Zr-2.5% Nb pressure tubes showed that the enhanced strength of the heat treated material warranted further development work. Further, availability of suitable furnaces in the United States which hitherto had been used for heat treating rocket motor cases provided added incentives.

A new development contract for 72 tubes was placed with the more successful of the two U. S. pressure tube fabricators.

By 1966 most of the earlier processing difficulties were solved. Significant advances were made in billet-forging and extrusion techniques. Evaluation of these tubes showed that our expectations had been fulfilled in both metallurgical properties and dimensional tolerances. At this time we were sufficiently confident to recommend heat treated

Zr-Nb as reference pressure tube material for the Kanupp and Gentilly reactors.

Although pressure tube materials are selected mainly on the basis of neutron absorption, strength and corrosion resistance, creep resistance in neutron fluxes is the most important property that determines the probable lifetime of pressure tubes when they are designed for optimum economy. Thus, neutron irradiation increases the creep rate of Zircaloy-2 by about 10 times whereas the Zr-2.5% Nb alloy is only increased by a factor of three to four. This means that a Zr-2.5% Nb alloy pressure tube will have a longer lifetime than Zircaloy-2 based on the time to reach a certain total strain at the same stress.

Because of its improved creep resistance the pressure tubes for Pickering III and IV reactors will be of cold worked Zr-2.5% Nb with a wall thickness of 0.160 inches as compared with 0.200 inches for the Zircaloy-2 tubes in Pickering I and II. For a 500 MWe reactor this decrease in wall thickness means a saving of about $2 million over the lifetime of the reactor. Based on a conservative estimate of 8000 MWe nuclear power generation capacity in Canada by 1980 the use of Zr-2.5% Nb pressure tubes in the power reactors that go into service between now and 1980 will reduce costs by about $30 million. To achieve this saving approximately $10 million has been spent since 1958 on research and development, about 40 per cent of this being on contracts with Canadian industry and universities.

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It will have been 12 years from the beginning of this work to the time when the first power reactor containing Zr-2.5% Nb tubes will be operating. This may seem a long time, but two factors have a profound influence on this: firstly, we had to provide assurance to the design engineer that the change from something he had experience with to something new was technically and economically sound; secondly, there is a long lead time between making the decision to use a new material and the time when the machine containing it becomes operational.

To date, all the tubes have been made in the United States and most of them by Chase Brass Company. For the last year and a half we have had a contract with Calumet and Hecla of Canada Limited (Wolverine Tube Division) to develop a pressure tube fabrication capability in Canada. By the end of 1968 we hope the company will qualify as a proven supplier. In addition, both Chase Brass and Noranda Limited (an all-Canadian company) recently expressed an interest in manufacturing pressure tubes in Canada. Noranda are already producing extruded tube shells for subsequent fabrication to fuel cladding and have a strong research and development centre to support such work. Although Wolverine should be a qualified supplier by the end of the year, they would have to install new equipment and modify their production facilities in London in order to complete a production order in Canada.

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A4. 4 HEAVY-WATER UPGRADING

Early in the development of heavy water reactors, it was realized that downgrading of heavy water, either by out-leakage of heavy water or in-leakage of light water, could become a major economic factor in their operational cost. An inexpensive process for upgrading heavy water was therefore a programme requirement.

Distillation or electrolysis may be used for the upgrading. CRNL has had experience with both methods and has made major improvements in electrolysis. A number of associated problems have been solved. Some of these relate to the purification of the water which, as recovered from leakage collection systems, often contains dirt and grease. During 1963 our operational difficulties with an enlarged installation pointed up inadequacies in technical knowledge of the process. An experimental electrolytic cell was installed and careful studies of both it and the production plant yielded data that permitted a vastly improved operation over other electrolytic installations. In particular, hydrogen-deuterium separation factors of 11 to 12 were obtained as compared to 8 or 9 previously. The electric current and therefore production from a cell, has been increased by a factor of five. Improved electrolytes have been developed and operation has been optimised. Since the basic separation mechanism is not yet fully understood, research and development is continuing with expectation of future gains in both separation factor and current density. Electric Reduction Co. of Canada

are assisting in this work under contract. All the engineering gains that have become possible as a result of the new technical knowledge have not yet been fully realized but the units are being altered where this is economically justifiable.

The Chalk River installation plays a critically important role in the Canadian nuclear power programme. The design has been chosen by CGE for use at the Kanupp Reactor under construction in Pakistan. When the volume of upgrading work justifies an installation either by an industrial enterprise or by the power plant owner, all relevant aspects of economic and technical significance may be determined from the CRNL operation.

A5. 1 ROTATING SHAFT SEALS FOR PRIMARY COOLANT PUMPS

The availability of a reliable high pressure shaft seal with controlled and preferably negligible leakage, for application in primary coolant system pumps, is of major importance to the CANDU reactor concept. Early experience with NPD primary pump commercial seals disclosed a requirement for more reliability and longer life. Basic CRNL experiments on seals, where the rotating faces were separated by a fluid film, proved that this design approach had real potential.

In 1961 Dilworth, Secord and Meagher were given a development contract to bring this concept to commercial realization. After a detailed analytical study, with associated laboratory testing, the hydrostatic concept evolved in which the thickness of fluid film between the faces could be predicted. Controlled leakage was set

at 0.4-0.5 gallons per minute and an operating life of 8-10 thousand hours was achieved. A major problem was the identification of compatible materials which would resist corrosion and erosion and which had suitable moduli of elasticity. Seals were installed in NPD pumps for comparative tests and are now in use in Douglas Point and ordered for Pickering.

It is of interest to note that Dilworth, Secord and Meagher is a fully Canadian-owned consulting engineering firm which is unique in that it operates a development laboratory. The development of the hydrostatic seal was one of their first major contributions to the AECL programme and was the principal product originally supporting the establishment of the DSM laboratory and of the associated manufacturing firm, Champlain Power Products. This seal package (which also includes the elliptical seal described on page 65) is being marketed around the world by Champlain Power Products.

A6.1 IN-REACTOR CREEP MEASURING DEVICES

The pressure tubes in a CANDU power reactor are exposed to high neutron fluxes during operation and a knowledge of how their creep rates are affected by neutron irradiation is essential to the designer if he is to gain full use of the potential strength of the material.

Apparatus has been developed to measure the creep rate of specimens of pressure tube alloys exposed under stress to a high neutron flux. In NRX, for example, this required a creep measuring machine with specimen, furnace and strain meter that would fit into a 10-foot long tube of

1.5 inch diameter. Much of the development work has been done by Orenda Engines Limited at a cost of about $2 million and the success represents a significant advance in in-reactor measurements. Two major design problems were the measurement of the strain and the maintenance of constant temperature. A length gauge was required that was stable under irradiation and capable of high sensitivity. Because gauges with electrical output signals tend to be affected by neutron irradiation and to drift, an air gauge was chosen for development. Air gauges are now produced for the creep machines with a sensitivity of 0.25 micro-meters (10^{-5} inch). Heaters and a sophisticated temperature control system have also been developed so that the heaters will survive long periods of time in the reactor while being controlled to $\pm$ 2°C.

The machines are in regular use to determine the effect of temperature and stress on the in-reactor creep of zirconium alloys. The air gauge developed for the creep machine has also been used to determine the rate of change of dimensions of UO_2 under irradiation.

As a result of this work two new companies have been born, Advanced Transducer Systems and Canadian Instrumentation Company, and Orenda Engines Limited have sold sensors to Oak Ridge National Laboratories for similar work on UO_2.

The creep machines permit continuous measurements of creep on specimens under irradiation. It is, however, also of importance to measure the internal diameters of typical

reactor pressure tubes in situ. Orenda Engines Limited has developed gauging equipment that is used for this purpose during reactor shutdown. Pressure tubes are emptied of fuel and coolant and the gauging head passed through. Three diameters are measured along the whole length of the pressure tube and the results are automatically recorded. The gauging heads also carry a profilometer which maps out marks on the tube wall such as mechanical scratches or fretting penetration.

The cost of development and hardware for this important device has amounted to about $400, 000. It is likely that there will be a continuing market for this type of equipment as more power reactors are commissioned. Operators will want to monitor the pressure tubes in each station so that the condition of the tubes will be known.

A6.4 SELF-POWERED NEUTRON AND GAMMA-RAY DETECTORS

Self-powered flux detectors are instruments for measuring high intensities of neutrons and gamma rays. They spontaneously produce electrical currents proportional to flux, and require no external source of electric power. They are particularly useful for mapping the spatial distribution of neutrons, and hence heat production, inside the core of a nuclear reactor. In nuclear power stations now under construction, this information is essential for operation at the highest design power levels.

Development of self-powered detectors was stimulated in 1962 by a paper in the "Soviet Journal of Atomic Energy". The CRNL contribution has been the development of materials

and fabrication techniques to produce a small rugged device that will withstand the radiation in high flux reactors. When the experimental project started, there appeared to be no urgent requirement for in-core detectors. However, detailed flux mapping within large reactor cores is proving desirable and self-powered detectors have come into wide practical use much more quickly than anticipated.

The unique advantages of these detectors are their small size, long life and reliability. They are also simpler and less expensive than alternative devices. Patents have been granted in the United States and Canada, and a Canadian manufacturer has been producing these detectors under license for three years. The present volume of business is approximately $150, 000 each year, much of it for export, and there are indications that it could easily grow by a factor of five and perhaps 10. More important, the new Canadian company, Reuter-Stokes of Canada, 50 per cent Canadian owned, was established to produce these flux detectors and other similar components and is acquiring advanced technology in what will become an increasingly important secondary industry.

Work at CRNL is continuing to extend this principle of radiation detection to a number of other fields, and to acquire a better fundamental understanding of the physical processes involved.

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A8.1 PROPERTIES OF FUEL MATERIALS

Although the feasibility of using UO_2 fuel elements with thin Zircaloy sheaths had been clearly demonstrated by 1962, the designs were conservative. A much more detailed understanding of the behaviour during irradiation was necessary in order to develop the full potential of fuel in the two important areas of fuel rating and neutron economy. Accordingly, research has been concentrated on clarifying those areas of ignorance about fuel material properties which have relevance to the economic design of UO_2 fuel. Some of these, namely thermal conductivity, release and re-entry of fission product gases, and swelling caused by irradiation are discussed below.

Knowledge of the temperature distribution across a fuel element is basic to any understanding of fuel performance, since temperature dictates fuel expansion, strength and the movement or release of the fission products created in the fuel by irradiation. The temperature distribution is determined by the heat-rate, the thermal conductivity of the fuel material, and the heat transfer coefficients at the fuel-sheath interface and the sheath-coolant interface. The thermal conductivity of the fuel during irradiation was studied by direct techniques (which necessitated development of thermocouples for measuring the very high temperatures involved, up to 2800^0C) and indirect techniques which depend on interpreting changes in the structure of the fuel. To assist interpretation of these changes, grain growth and densification of the UO_2 as a

function of temperature, pressure and irradiation were extensively studied.

Gaseous fission products created in the UO_2 may form bubbles and so cause swelling of the fuel or can escape from the UO_2 and develop pressure inside the sheath. It is essential to be able to design fuel elements so that neither swelling nor gas pressure subjects the sheaths to undue stresses leading to failure. Gas release has been found to be affected by many factors, such as temperature, oxygen to uranium ratio, irradiation time and migration along the very high temperature-gradients which occur in operating fuel. Even now no satisfactory theory exists to account for all the experimental observations but a sufficient body of information has been developed to enable us to predict gas release with reasonable certainty. The re-entry of gas into the UO_2 under irradiation although not yet understood is potentially a very beneficial phenomenon as it may limit the gas pressure in fuel elements i.e., the release of gas from the hotter regions of the fuel will be compensated by the re-entry of gas into the colder regions.

During irradiation the UO_2 expands and the volume available to the gas decreases. A simple model describing UO_2 expansion was evolved from observations on irradiated fuel elements. This was used in calculations of the free volume remaining inside the element after fuel expansion. Coupled with the information about gas release this enables the gas pressure developed inside fuel elements to be

calculated. Measurements of gas pressures during irradiation using specially developed instrumentation fit with the calculations, giving some confidence in design criteria.

To date, the CANDU system of reactors has required design for burn-ups of less than 14,000 MWd/TeU. Recently, however, we have been considering very much higher burnups, and therefore have to take into account the swelling caused by gaseous fission product bubbles and solid fission products. We are attempting to control this swelling by directing it into preformed voidage in the fuel, and simultaneously are gaining an understanding of the physical processes by examining highly irradiated samples in the electron microscope and studying the balance between creation of bubbles and the re-entry of the gases into the UO_2 during the irradiation.

This type of applied research work on fuel is carried out on less than full size specimens in the NRX reactor and thus NRU is fully available for work on problems unique to full size fuel bundles.

We hope to maintain ourselves in the position of being able to give designers of future reactor systems quantitative recommendations on fuel element design for optimum performance, thus obviating the wasteful trial-and-error approach to each new requirement. Only in this way will Canadian fuel fabricators remain capable of supplying the world's lowest cost fuel.

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Work of a similar nature has been done on uranium carbide, mixtures of uranium and plutonium oxides, thorium oxide, mixtures of thorium and plutonium oxides and uranium-silicon alloys.

A9.7 FUEL REACTIVITY VS BURNUP

A major advantage of the Canadian heavy water moderated, natural uranium reactors is their low fuelling cost and this hinges on attaining a relatively high burnup (i.e., integrated heat output per unit weight) from the fuel.

The limit on burnup may be set by fuel failure or by a reduction in fuel reactivity to an extent that the chain reaction cannot be sustained. Fuel developed at Chalk River has successfully demonstrated adequate physical integrity against failure and so the burnup is determined by reactivity.

The reactivity results from a delicate balance between several processes, principally the destruction of fissile material and the resulting production of neutron absorbing fission products (negative contributions) and the conversion of fertile material, e.g., U-238, to fissile material, e.g., Pu-239, (positive contribution). At the beginning of the nuclear power programme the available information indicated that burnups from natural uranium could be high enough to make it competitive with enriched uranium. However, there were many uncertainties in the data and there might well be unsuspected stumbling blocks. Moreover accurate data were necessary in designing for optimum balance.

An important Chalk River project has been improvement in knowledge of nuclear data (fission cross-sections, neutron

emission, fission product yields, etc.) and their application to burnup predictions. The magnitude of the required effort far exceeded Chalk River resources.

Much basic information has been obtained through international co-operation. Chalk River has played a major part in stimulating a concerted international effort, first through a tripartite committee (U.K., U.S.A., Canada), then through a European-American committee, and recently world-wide efforts through the IAEA. Chalk River contributed some basic results, important methods of correlating the data for use, and has had a leading place in measurements of irradiated fuel reactivity and chemical composition.

A milestone in this programme is the satisfactory agreement between computer predictions of the reactivity changes and attainable burnup in NPD and the operational results. This gives confidence in the burnup estimates for the large commercial stations.

A10.2 TWO-PHASE HEAT TRANSFER AND THE EVOLUTION OF THE BLW CONCEPT

In the first generation of Canadian power reactors the coolant transferring heat from the fuel to the steam generator is heavy water. This is an expensive coolant which further complicates operations because of the toxicity of its tritium content. Nevertheless, its low neutron capture rate promises low power costs. The obvious alternative of using natural (light) water as coolant is attractive only if the amount of water can be kept small to reduce neutron

capture.

As part of the programme to determine the feasibility of using light water coolant, two small hydraulic circuits or "rigs" were built, one in the NRX reactor where heat could be supplied by nuclear fuel and one in the laboratory where simulated fuel could be heated electrically. Work with these rigs and associated engineering and economic studies of steam, fog and boiling water cooling showed that boiling was the most promising. On the basis of these and other analyses the Power Reactor Development Program Evaluation Committee (PRDPEC) recommended that the boiling light water CANDU concept should be pursued as the alternative to the existing pressurized heavy water concept.

A reactor using boiling light water coolant was developed from the conceptual design stage to become the Gentilly CANDU-BLW-250 station.

The boiling heat transfer studies centered mainly on "dryout"- the condition in a boiling system when the fuel surface is no longer wet - since above the dryout point the temperature rises rapidly and fuel cladding may react with the steam and be destroyed. The dryout point could not be predicted accurately enough for design purposes and experimental measurements were required on full size test clusters beyond the capabilities of the Chalk River rigs. Under the terms of the U. S. /Canada co-operative agreement on heavy water reactors, a successful set of experiments was carried out on a large rig at Columbia University. At

the same time a rig was built in Hamilton by Canadian Westinghouse, under contract with AECL, and further tests were carried out. To confirm that dryout in a reactor could be predicted from measurements in an electrically heated rig, measurements were made in a large fuel test-loop in the NRU reactor. As none of these experiments could simulate the Gentilly reactor conditions completely, much analytical effort was still required to predict the performance. An exchange agreement with the United Kingdom gave us details of their analytical methods and experimental information against which to check our own methods.

Now that the design of a boiling water reactor is well in hand, continued effort is needed to extend and generalize our knowledge of boiling heat transfer. Planned improvements to our computing and experimental facilities, combined with the technology acquired in the Chalk River and Hamilton laboratories, will provide the background needed for designing future generations of boiling water cooled reactors.

A13.3.1 GERMANIUM GAMMA-RAY SPECTROMETERS

Few instruments have had as much impact on their particular fields of science as that of the germanium spectrometer on nuclear science. Much of the early development work on this device was carried out at CRNL, and at RCA Victor in Montreal on CRNL development contracts. This device first became known in 1962 and development work proceeded rapidly at RCA and CRNL during late 1962 and 1963. The

spectrometers were quickly put to use in physics experiments at CRNL and in 1963 and 1964, Drs. G. T. Ewan and A. J. Tavendale published several papers, including a comprehensive paper in the Canadian Journal of Physics, showing the method of preparation, the usefulness and the potentialities of this important new detector.

Electrically, this detector is a simple rectifier made from a large piece of highly pure single crystal of the semiconductor element germanium. Special manufacturing techniques are involved including "lithium drifting" which produces a large sensitive volume for the absorption of gamma-rays. The electrical signal produced when a gamma-ray is absorbed gives a precise measure of the gamma-ray energy - with the aid of a great deal of very sophisticated electronic equipment. The resolving power of a germanium detector for the gamma-rays emitted by a Cobalt-60 source is better than 0.2 per cent. The nearest comparable spectrometer (a scintillator) has a resolving power for the same gamma-rays of about 6 per cent.

Electronic components suitable for use with other types of detector proved to be completely inadequate for germanium detectors. A whole range of new electronics had to be developed very quickly. These range from tiny transistor amplifiers to large computer controlled analysis and data handling systems.

The basic germanium material was originally developed for transistors and similar devices which in recent years

have tended to ever smaller sizes. The active volume of many transistors is about one billionth of a cubic centimeter. Germanium spectrometers in contrast must be of large volume because high efficiency is needed in much of the work for which they are suited. At CRNL, detectors with sensitive volumes up to 50 cubic centimeters are in daily use and larger ones are needed. For such detectors to have a high performance extremely good crystals are necessary.

Small defects and impurities which would have little effect on transistor production cannot be tolerated in detector crystals. Only 5 to 10 per cent of crystals sold as suitable for making detectors are capable of being made into spectrometers having close to the best possible performance. Because of the need for larger crystals of optimum quality, a project to grow germanium crystals up to 8 cm diameter and up to 1000 cubic centimeters volume has been started at the Ontario Research Foundation. So far only a few crystals have been grown and much work remains to be done. However, all crystals have been of the desired size, and a small piece of one of the most recent crystals was made into a high quality spectrometer.

Germanium spectrometers are now in use in laboratories throughout the world and are made commercially by firms in several countries including Canada. Their use will increase in laboratories and also in the fields of activation analysis and nuclear reactor monitoring. Further gamma-ray detector developments can be expected, not only in

the germanium type but in types made from other semi-conductor materials.

B. CRNL Basic Research Projects

(An asterisk indicates that a case history has been prepared.)

B1. Nuclear Research

B1.1 Experimental Studies using Reactors.

B1.1.1 Gamma radiation following capture of thermal and resonance neutrons.

B1.1.2 Nuclear structure and photo fission by use of variable energy gamma-ray beam.

B1.1.3 Precision gamma-ray energy measurements; determination of fundamental physical constants.

B1.1.4 Thermal neutron fission; yields, fragment ranges, neutron emission.

B1.1.5 Thermal and epithermal neutron absorption and capture cross sections.

B1.2 Experimental Studies using Accelerators.

B1.2.1 14 MeV neutron inelastic scattering by time-of-flight methods.

B1.2.2 Fast neutron reaction cross sections by radiochemical methods.

B1.2.3 Heavy ion reaction cross sections.

B1.2.4 Measurements of (d, py), (d, pf) and (d, tf) reactions with a magnetic spectrograph with spark chamber.

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B1.2.5 Fission mechanism by channeling - blocking techniques.

B1.2.6 Particle capture reactions using a windowless gas target.

B1.2.7 Angular correlations in nuclear reactions using multicounter arrays.

B1.2.8* Nuclear lifetime by Doppler Shift methods.

B1.2.9 Nuclear quadrupole moments from Coulomb excitation experiments.

B1.2.10 Decay properties of isomeric states and short-lived nuclei.

B1.3 Experimental Studies with Irradiated Material

B1.3.1 Precision measurements of radioactive source strengths.

B1.3.2 Measurements of radioactive decay constants.

B1.3.3 Decay schemes of radioactive nuclei by beta and gamma spectroscopy (energies, spins and parities of excited states).

B1.4 Theoretical Nuclear Physics

B1.4.1 Binding energies of very light nuclei using Faddeev equations.

B1.4.2 Methods for determining properties of nuclear states within the shell (independent particle) model for light nuclei.

B1.4.3 Approximations to the shell model using self-consistent method and group theory: the interpretation of a shell model state in terms of collective models.

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B1.4.4 Extensions to the shell model from the general many-body theory.

B1.4.5 Short range particle correlations in nuclei and their significance for binding energies and the interpretation of high energy electron scattering data.

B1.4.6 Studies of nuclear reaction mechanisms.

B1.5 Theoretical Reactor Physics

B1.5.1 Study of the dynamics of xenon poisoning of reactors and its control by the use of ING-type neutron sources.

B1.5.2 Transport theory calculation of neutron spectra in reactor cells and in ING.

B1.5.3 One-velocity multi-region spherical-harmonic calculations of neutron fluxes in reactor cells.

B1.5.4 Calculation of fast neutron fluxes in reactor irradiations.

B1.5.5 Calculation of thermal neutron fluxes from moderated antimony-beryllium systems.

B1.6 Theoretical Studies Related to ING

B1.6.1 Space charge effects in the buncher for a proton linac.

B1.6.2 Theory of coupling in a coupled-cell linac tank.

B1.6.3 Investigation of desirable pole shapes for quadrupole magnets.

B1.6.4 Accelerator parameters by cost minimization.

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B1.7 Other Activities in Mathematics and Theoretical Physics

B1.7.1 Study of circumferential ridging of fuel elements.

B1.7.2 Calculation of the deposition of radioactive material in a reactor coolant system.

B1.7.3 Mathematical models for calculating biological dose in humans from uptake of radioactive material.

B1.7.4 Theory of beta-ray spectrometers.

B1.8 Tandem Accelerator Physics

B1.8.1 Measurement of equilibrium charge states of heavy ions passing through solid and gas strippers (1963).

B1.8.2 Studies of negative ion production.

B1.8.3 Investigation of use of SF_6 in accelerators.

B1.9 Space Physics

B1.9.1 Continuous monitoring of cosmic ray neutron flux for correlation of modulations with solar activity.

B1.9.2 Provision of modulation data for the USAF 4th Weather Wing Space Forecast Facility, NORAD, Colorado, for US Man-in-Space Programme.

B1.9.3 Quiet and active sun latitude survey using mobile laboratory.

B2. Materials Research

B2.1 Crystal Structure by Neutron Diffraction using the NRX Reactor

B2.1.1 Crystal assembly adaptations leading to improved spectrometer performance.

B2.1.2 Structures of pyrochlores and related compounds.

B2.1.3 Structures of magnetic alloys.

B2.2 Lattice Vibrations in Crystals (simple metals, alloys, molecular crystals, ionic crystals, semiconductors, and ferroelectrics) by Neutron Inelastic Scattering using the NRU Reactor

B2.2.1 Interatomic forces.

B2.2.2 Interactions between lattice vibrations and other lattice vibrations, magnetic vibrations and electrons.

B2.2.3 Phase transitions.

B2.2.4 Zero and first sound in solids.

B2.3* Magnetic Excitations in Crystals by Neutron Inelastic Scattering using the NRU Reactor

B2.3.1 Interactions between magnetic atoms.

B2.3.2 Interactions between magnetic and other excitations.

B2.3.3 Spin-orbit interactions and crystal fields.

B2.3.4 Phase transitions.

B2.4 Structural Dynamics of Liquids

B2.4.1 Measurement of inelastic neutron scattering distribution for liquid argon.

B2.4.2 Experimental study of superfluid liquid helium by neutron inelastic scattering.

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B2.4.3 Theoretical studies of slow neutron scattering in atomic and molecular liquids (and associated problems in light scattering and infra red absorption).

B2.5 Studies of Momentum Distributions of Electrons in Condensed Matter by Annihilation-Radiation Angular Distributions

B2.6 Ion Penetration and Atomic Collision Processes in Solids

B2.6.1* The movement of ions in amorphous and crystalline solids, with emphasis on channeling in crystals.

B2.6.2 Factors influencing the positions assumed by foreign ions when implanted as energetic ions in semi-conductors.

B2.6.3 Theory of electronic stopping of ke V ions (Z_1 oscillations)

B2.6.4 Theory of sputtering of amorphous targets by heavy ions.

B2.7 Atomic Migration in Solids

B2.7.1 Solute and self diffusion in metals and ceramics.

B2.7.2 Migration of point defects and defect clusters produced in crystalline solids by neutron, proton and heavy ion irradiation.

B2.7.3 Plastic deformation and recovery processes in metals.

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B2.7.4 Use of nuclear reaction techniques to measure atomic migration in thin oxide films.

B2.8 Structure-Sensitive Properties of Materials

B2.8.1 Relation between microstructure of metals and their mechanical properties.

B2.8.2 Nucleation and growth of gas bubbles in irradiated metals and effect on mechanical properties.

B2.8.3 Direct observation of atomic-size defects in solids using high resolution electron microscopy techniques.

B2.9 Physics and Chemistry of Surfaces

B2.9.1* Processes controlling oxidation rates of metals.

B2.9.2 Effects of irradiation on the kinetics of metal oxidation.

B2.9.3 Electrical properties of oxide films at elevated temperatures.

B2.9.4 Study of oxide films on metal sub-strates by electron microscopy and electron diffraction.

B2.9.5 Chemical interaction of thin oxide films with metal sub-strates.

B2.9.6 Factors influencing the initiation and propagation of cracks in metals and metal-ceramic composites.

B2.9.7 The mechanism of oxide growth at metal electrodes.

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B2.9.8 Factors affecting the sorption of fission product ions from aqueous and organic media on metal and metal oxide surfaces.

B2.10 Effects of Ionizing Radiations on Materials

B2.10.1 The mechanism of the initial chemical changes produced in vapours by electron pulses.

B2.10.2 The study of radicals and electrons condensed from vapours irradiated with helium ions, using electron spin resonance spectroscopy.

B2.10.3 Charge transfer and electron capture processes in the radiolysis of hydrocarbons.

B2.10.4 The properties of electrons, ions and radicals produced in organic glasses and single crystals by gamma-radiation.

B2.10.5 The effects of dose, dose-rate, linear energy transfer and additives on the mechanism of radiolytic reactions, including dosimetry.

B2.10.6 The mechanism of the interaction of beta-particles with tissue equivalent materials.

B2.10.7 The mechanism of the interaction of radiation with low atomic number elements of biological significance.

B2.10.8 The radiolysis of simple molecules absorbed on solids of large surface area.

B2.10.9 Radiation damage from neutron and proton bombardment of metals, ceramics and semi-conductors.

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B2.10.10 Direct observation of radiation damage produced in metals during ion bombardments in the electron microscope.

B2.11 Hydrogen-Deuterium Isotope Effects

B2.11.1 The influence of electrode characteristics on the electrochemical H-D separation factor in aqueous systems.

B2.11.2 The deuterium isotope effect and the molecular dynamics of organic-water systems.

B2.11.3 Hydrogen bonding and isotope exchange in in non-polar solvents.

B2.12 Analytical Science

B2.12.1 Physical and chemical methods for the analysis of materials used in the atomic energy programme, e.g. heavy water, reactor fuels and structural materials.

B2.12.2 Nuclear methods such as radioactivation and nuclear scattering for analytical purposes.

B3. Biological Research

B3.1 Mechanisms of Sensitivity, Resistance, Repair and Protection of Living Systems to Radiation

B3.1.1 Experiments to describe effects on a subcellular and molecular level.

B3.1.1.1 Biochemical events in cells following irradiation.

B3.1.1.2 Characterization of mammalian cell membrane structure and its changes following irradiation.

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B3.1.1.3 Characterization of basic proteins in cells, their biological role, and effects of irradiation.

B3.1.1.4 Repair of radiation induced damage in DNA of micro-organisms.

B3.1.1.5 Repair of damage in DNA produced by radiomimetic agents.

B3.1.2 Experiments on whole organisms.

B3.1.2.1 Lethal sectoring in yeast following irradiation.

B3.1.2.2 Genetic studies of repair of mutated DNA in yeast.

B3.1.2.3 Protective role of calcium in promoting survival of irradiated rats.

B3.1.2.4 Control mechanisms in tumour growth.

B3.1.2.5 Protective role of bone marrow transplants in animals following irradiation and identification of stem cells.

B3.2 Consequences of Radiation on Living Systems

B3.2.1 Congenital malformations in embryos following irradiation of fish sperm.

B3.2.2* Record-linkage by computers to study mutation incidence in human populations.

B3.2.3 Radiation dose effects on mutations in insects.

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B3.2.4 Radiation induced injury in insects.

B3.3 Effects of Radiation and Radioactive Substances on the Environment

B3.3.1 Rate of movement of radioactive substances through water, soil and air.

B3.3.2 Fate and transport of radioactive substances through the food chain of man.

B3.3.3 Dye-dilution studies to investigate the dilution regimes of rivers and lakes.

B3.3.4 Studies to obtain information to carry out safe and effective radioactive waste management.

B3.4 Uses of Radiation and Radioactive Substances

B3.4.1 Procedures for the identification and measurement of important biological macromolecules.

B3.4.2 Radioactive labelling of blackflies to study population, dispersal, and migration.

B3.4.3 Study of the evaporation of water from lakes using tritiated water.

B3.4.4 Study of the movement of water through the biosphere by measuring natural and bomb tritium.

B3.4.5 Study of the metabolism of water in humans using tritiated water.

B3.4.6 Dating of ground water by measurement of tritium in tree rings.

B3.4.7 Study of atmospheric diffusion using argon-41.

<u>Appendix 14</u>

B3.5 Detection and Measurement of Radiation and Radioactive Substances

B3.5.1 Measurement of airborne radioactive iodines.

B3.5.2 Measurement of tritiated water in a reactor environment.

B3.5.3 Dosimetry of neutrons by fission fragment damage in mica, glass and plastic.

B3.5.4 Dosimetry of radiation by thermoluminescent detectors, such as lithium fluoride.

CASE HISTORIES

B1.2 EXPERIMENTAL STUDIES USING ACCELERATORS

B1.2.8 Nuclear lifetimes by Doppler Shift methods:

In much the same manner as atoms were studied by atomic spectroscopy, nuclei are studied by nuclear spectroscopy. However, the techniques of nuclear spectroscopy are very different. They involve the use of large particle accelerators and complex detection systems to measure the gamma rays or particles ejected during a nuclear reaction.

Much of the study of Nuclear Physics has taken the form of comparing with experiment the predictions of various models of the nucleus for the spectroscopic properties, energy, angular momentum and parity. It is necessary to use models because calculations based on fundamental properties, such as the forces between the nucleons that make up the nucleus, are impossible at the present time. There are currently several

models, for example the shell model, the collective model, the unified model and the SU_3 model, and it is of great interest to evaluate their applicability. One critical test of the validity of a model lies in its prediction for the electromagnetic transition rate from one excited state to another. These rates can be determined if the lifetime of the excited state is known but as many of the interesting lifetimes lie in the range 10^{-9} to 10^{-14} secs, special techniques must be used to measure them.

Because CRNL had available to it large detectors of gamma radiation and an accelerator capable of accelerating a variety of projectiles to precisely controlled energies, CRNL was in a good position to exploit one of these techniques, the shift in the energy of a gamma ray when it is emitted from a moving source (the Doppler effect, known to everyone who has listened to the change in pitch of the whistle of a passing train). The size of this shift in energy depends on the velocity of the moving source, and for the recoil velocities typical of reactions induced by an MP Tandem accelerator the shift is between 0.5 and 5 per cent. The advantage of the Ge(Li) detector is that it combines energy resulution good enough to measure such small changes with a reasonable detection efficiency.

Two rather different methods are used. The first, called the Doppler Shift Attenuation Method, makes

use of the fact that the slowing down times of the nuclei recoiling from a nuclear reaction are about 10^{-13} seconds in a solid material and differ in different materials. The time depends on the nature of the recoiling ion and the stopping material so that a range of lifetimes from 5×10^{-12} secs to about 10^{-14} seconds can be determined in this way.

In the second method, the nuclei excited by a reaction recoil freely in a vacuum (after leaving the target) until they are quickly stopped, in about 3×10^{-13} secs, by a movable plunger. Because of the Doppler shift, the energies of the gamma rays emitted by the stopped and moving nuclei are different. Knowing the velocity of the recoiling ions, and hence the time it takes them to reach the plunger, it is possible to obtain lifetimes in the range 10^{-9} to 10^{-12} secs. Once again it is necessary to have the good energy resolution of the Ge(Li) detectors and the ability to accelerate heavy ions to precisely known energies.

The lifetime range covered by Doppler Shift measurements is well suited to studying electric quadrupole (E2) and electric octupole (E3) transitions between bound levels of nuclei in the s-d shell, that is from ^{16}O to ^{40}Ca. The studies have shown that in nuclei near ^{24}Mg, there are certain bands of levels, and the E2 transitions between the levels of any given band are greatly enhanced. These bands are similar

to the rotational bands observed in heavy nuclei and show that collective effects resulting in quadrupole deformations are important in light nuclei. The enhancements are about a factor of 20, in other words the rate is 20 times that expected from the transition of a single nucleon. The experimental data on E3 strengths are less extensive but these appear to be large near ^{16}O, decrease towards ^{24}Mg and then increase again. Studies of the E3 strengths will show whether octupole and higher order deformations are important in these nuclei.

B2.3 MAGNETIC EXCITATIONS IN CRYSTALS BY NEUTRON INELASTIC SCATTERING USING THE NRU REACTOR

Neutron inelastic scattering gives information about the relationship between the energy and momentum of the wave-like motions in a crystal. Examples of such wave-like motions are sound waves which are very low frequency lattice vibrations (phonons). Magnetic systems show analogous wave-like modes (magnons). Neutrons are capable of exciting or detecting such vibrations which have frequencies in the neighbourhood of 10^{12} cps. Studies of magnons give information on the interactions which determine magnetic properties. The information derived pertains largely to phenomena at the fundamental, wave mechanical level but properties of macroscopic practical interest may also be elucidated.

Studies of the relationships between energy and momentum for phonons and magnons in uranium dioxide (UO_2) have contributed to a basic understanding of the properties of

this industrially important material. A theory derived from the phonon behaviour can be used to calculate lattice specific heat and other thermodynamic quantities. Measurements of magnetic excitations near and below 30°K, the temperature at which the lattice becomes antiferromagnetic, have revealed a strong interaction between magnons and phonons and have led to deeper insights in the theoretical description.

Several experiments have been carried out on materials containing cobalt ions either naturally as a molecular constituent or artificially as a dopant.

Among the materials studied in this series is cobalt fluoride which has a body-centered tetragonal structure and becomes antiferromagnetic below 37.7°K. Experiments on this complicated material were carried out at several temperatures, above, near and below this transition temperature. An important conclusion from these measurements is that the collective magnetic excitations continue to occur well above the transition temperature. This surprising result is in disagreement with current theories of magnetism.

In another experiment the low-lying lattice vibrations and magnetic excitations of cobalt oxide were studied near its antiferromagnetic transition temperature at 293°K. The lattice vibrations are similar to those of rock salt which has the same crystal structure. For the paramagnetic phase (above 293°K) analysis of the neutron scattering results revealed that one of the fundamental interactions of the cobalt-ion electrons (spin-orbit interaction) was unexpectedly much less in the crystal than its value in the free ion. In the

antiferromagnetic phase, analyses of the neutron scattering results gave information about the lower energy levels of the Co^{2+} ion.

In a third experiment of this group, the spin wave magnetic excitations of MnF_2 doped with 5 per cent of CoF_2 were studied at 4.2°K. In addition to excitations characteristic of the pure MnF_2, a higher frequency mode was observed that is identified as a localized magnetic mode associated with the cobalt impurities. This behaviour can be accounted for by a theory involving a cluster of host ions surrounding the impurity ion.

Neutron scattering experiments in the rare earth metals have contributed to knowledge of their dynamical properties. In general, rare earth metals are neither ferromagnetic nor anti-ferromagnetic but their magnetic moments can align in more complicated patters such as cones and spirals and the material may assume more than one magnetic phase depending on the temperature. The relationship between energy and momentum of the magnetic excitations has been measured in erbium (conical structure) and holmium (spiral and conical). The results give information on the magnitudes of magnetic interactions and the internal electric fields in these materials.

B2.6 ION PENETRATION AND ATOMIC COLLISION PROCESSES IN SOLIDS

B2.6.1 The movement of ions in amorphous and crystalline solids, with emphasis on channelling in crystals: A matter of fundamental interest and practical importance in nuclear and material science is the

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distance through which a heavy ion, such as a xenon atom with an electron removed, can move in a solid before losing all its initial energy and coming to rest. Information on this topic contributes to our understanding of such things as the mechanism of energy loss, the nature of forces between atoms in solids, and the structure of solids.

N. Bohr, in 1948, and other scientists in the interim have made theoretical contributions to the subject but because the distances involved are very small, about 0.0001 cm, tests of the theory had to wait until the late 1950's for the development of suitably refined methods of measurement. Such measurements, using a combination of radio-tracer techniques and an electrochemical method for sectioning solids a few atom layers at a time, were in progress in CRNL laboratories from 1957 to 1962 and were giving much information about the distribution of ranges of ions in amorphous and polycrystalline solids. On the whole our observed ranges confirmed theoretical predictions but toward the end of this period we found that a small fraction of the ions penetrated to depths as much as 10 times the mean range in polycrystalline material. This was a completely unexpected observation, unaccounted for by existing theories.

The explanation came from scientists at USAEC's Oak Ridge Laboratories who had been making

rigorous calculations of range distributions for heavy ions in crystals using a computer. They found that their calculated distributions had a very penetrating component whenever a regular arrangement of atoms was used in their computations and they suggested that when an ion enters a crystal within a small angle of a close packed row or plane it becomes channelled, i.e. it is steered along the open tunnels or channels in the crystal by many successive collisions with the atoms in the rows that form the channel.

Further experimental tests were quickly mounted at CRNL and elsewhere. These fully confirmed the channelling concept. An accurate theoretical description of the steering mechanism has since been developed, largely by Danish scientists. Further theoretical and experimental research is in progress at CRNL and other laboratories, so that channelling is now established as a rather general phenomenon occurring in crystals with all atomic particles with energies from 0.1 to 100 MeV.

A consequence of channelling is that processes requiring a close encounter between ions moving in the channel and atoms in the crystal lattice are prohibited, although reactions will occur in well-understood ways when the ions are moving at random angles with respect to the crystal lattice. Nuclear reactions, x-ray production and wide-angle Rutherford scattering are typical of such processes. By applying

our knowledge of these processes to the observations obtained from channelling experiments, information about the position of impurity atoms in crystals, crystal structure and orientation, lattice defects and radiation damage and annealing has been deduced at CRNL. Furthermore, the line of argument can be reversed and channelling results can lead to information about nuclear processes. This approach forms the basis of a research project on nuclear fission at CRNL.

Thus channelling is now a rather well understood phenomenon. It is a fascinating example of the interplay between nuclear and materials science and is certain to contribute to our further understanding of these matters.

Several fruitful international conferences on ion penetration and atomic collision studies have been held. The latest one was at Chalk River in 1967. Representatives from Canadian universities and industry and a number of visitors from other countries attended.

B2.9 PHYSICS AND CHEMISTRY OF SURFACES

B2.9.1 Processes controlling oxidation rates of metals: One of the most significant advances contributing to the establishment of economic nuclear power plants has been the development of zirconium alloys having low oxidation rates in water at 300°C. Such alloys are used in Canadian reactor cores for fuel

sheathing and for pressure tubes. If future reactors are to be operated at appreciably higher coolant temperatures, say 500°C, new, more corrosion-resistant, alloys must be perfected.

Zirconium is a very reactive metal chemically with a high affinity for oxygen and nitrogen. It owes its compatibility with high temperature water to the formation of a protective oxide layer only a few microns thick. Thus there is a large incentive to search for a comprehensive understanding of the mechanisms controlling the growth and properties of such thin oxide films on zirconium and its alloys. As a consequence a basic research project was launched to investigate the thermal oxidation of zirconium and possible irradiation effects on the processes involved.

One of the first questions to be answered was on the relative mobilities of the zirconium and oxygen ions in the oxide film. Radioactive rare gas atoms were injected to a definite depth of a few hundred Angstroms below the surface of the metal in a mass separator. The metal was then anodized and successive thin layers of the oxide of about 20 Å were removed by vibratory polishing. A measure of the residual radioactivity in these layers indicated that oxygen was the mobile species. Other studies on anodic films showed that movement of zirconium ions was less than 1 per cent of the total.

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Oxygen ion transport was examined in further detail by oxidizing alloys first in normal oxygen and then in O^{17}-enriched gas. The resulting O^{17} diffusion profile was determined by irradiating the specimens in a Van de Graaff accelerator with He^3 ions and measuring the alpha particles emitted from the reaction $O^{17}(He^3, a)O^{16}$. From the results it was deduced that oxygen was being transported by a line or surface diffusion process perhaps along crystallite boundaries at a rate of some 10^4 times that for bulk diffusion at 400-500°C.

Examination of thin films by transmission electron microscopy has revealed that the oxide is not completely crystalline but contains some portion of amorphous material which varies with the alloy composition. Since appreciable oxygen ion transport may be occurring via these amorphous regions, the oxidation rate could be markedly affected perhaps by changing the nucleation and growth of crystallites within the oxide film.

Orientation of the crystallites on the metal sub-strate may also be of importance. Hence detailed crystallographic and morphological studies of expitaxial zirconia are under way using electron diffraction together with transmission and scanning electron microscopy.

Electron transport through oxide films on zirconium and Zircaloy-2 has been shown to occur primarily at a few sites where the resistivity is abnormally low.

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These correspond with the sites of intermetallic particles in Zircaloy-2 but even in crystal bar zirconium there are still about 100 sites per cm^2 which are thought to be coincident with areas of impurity segregation.

Several techniques have been developed to determine the nature and frequency of defects such as cracks and pores in zirconia films. The scanning electron microscope has proved particularly valuable for studying surface topography and to examine defects in the 100-1000 Å wide region. Mercury porosimetry and impedance measurements have provided useful data also since they revealed the presence of small pores of less than 100 Å radius which had not been observed in the electron microscope.

Now that a better understanding of the oxidation process has been obtained in the absence of ionizing radiation, in-reactor experiments are being planned. The results should provide the basis for a sound approach to the specification of the desired alloys of the future.

B3.2 CONSEQUENCES OF RADIATION ON LIVING SYSTEMS

B3.2.2 Record linkage by computers to study mutation incidence in human populations:

In addition to carrying out more conventional kinds of research on the biological effects of ionizing radiation, AECL has developed computer methods for studying the consequences of naturally occurring mutations in human populations.

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Information on the importance of naturally occurring mutations in man is required in order to predict the consequences of a radiation-induced increase in the rate at which the mutations occur. Human pedigree information is needed for such studies and, to obtain this in larger quantities than would be possible by conventional means, computers have been used to compile family histories from existing large files of vital and health records already available in machine readable form. In essence, the method makes it possible to match and "link" together independently derived records relating to the same individuals or families.

Since rapid procedures for "record-linkage" were first demonstrated at Chalk River, other projects using similar methods for a variety of research purposes involving follow-up of people have been initiated at a number of centres around the world (Pavia, Oxford, Reykjavik, Maryland and Honolulu). There have been two international conferences on record linkage. Official reports on its uses for medical research have now been produced in Britain, Northern Ireland, the United States and Canada, and by the World Health Organization.

A unique feature of this use of computers is that the machine is asked to exercise something akin to the subjective judgment of a human filing clerk. Since no universal system of personal identity numbers is

as yet in general use in Canada, the computer has to decide on the basis of names, ages, birthplaces, and such, whether a pair of records does, or does not, relate to the same person or family.

Currently linked into family groupings by these methods are records of live births, stillbirths, registered handicaps and deaths, together with parental marriage records, pertaining to some 200,000 children born in British Columbia over a six-year period (1953-58). The family files are now being extended to include 1,000,000 children born over a 20-year period (1946-65), and plans are being tested for building multi-generation pedigrees using the marriage records as links between the generations.

Even in this early stage the study has yielded a steady flow of data of many kinds, relevant both to the initial objective and to other scientific questions.

The cost of the approach will decline as multiple uses are found for the linked files of records. For example, family linkage of the vital records can also provide detailed information on the patterns of family formation, of kinds currently sought by demographers and previously unobtainable. Another use that is being considered for the linked vital records is to follow up miners who may have been exposed to radon to determine the risk of death from respiratory cancer.

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AECL has collaborated with a number of other government agencies in Canada to encourage more general use of the approach so that future applications will become increasingly economical.

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WHITESHELL NUCLEAR RESEARCH ESTABLISHMENT

The period 1962 to the present represents the period of inception and growth of WNRE. During the first formative years the main programme was the development and proving of the organic-cooled CANDU concept. This work started at CRNL; from 1963-65 the programme was pursued both there and at WNRE; by mid-1965 the total effort had moved to WNRE. The end of that year saw the culmination of much of the development in the successful startup of the WR-1 reactor. From then to the present the reactor has afforded a striking demonstration of the technical feasibility of the organic-cooled concept.

During 1966, the organic reactor project began to be de-emphasized within AECL and effort was switched to new projects, many of which had their genesis in the organic programme. Research and development in the field of nuclear materials science is now the primary role of WNRE. Its purpose is to develop materials for nuclear power reactors that will stand up to considerably higher temperatures than do the materials developed to date.

Major projects are listed below. Most were in existence, or were started, between 1966 and 1967; the starting dates of newer projects are indicated in brackets. The types of project now being undertaken illustrate the changed role of the WR-1 reactor from a test-bed for the organic-cooled reactor concept to that of a highly utilized materials test reactor. This is being accomplished by uprating thermal flux, by supplying special facilities in which high fast neutron fluxes are available and by the addition of loop facilities. For the future, increasing the core size from 37 to 55 sites will also

greatly improve its usefulness, with better return from its unique advantage of high temperature operation.

C. WNRE Research and Development Projects

C1. Reactor Coolant Technology

C1.1 Radiation Chemistry

C1.2* Purification and control of impurities in organic coolant

C1.3 Mass transfer and film formation

C1.4* Toxicology of organic coolant

C1.5* Radiolysis

C1.6 In-line analytical instrumentation

C2. Fuels

C2.1* Uranium carbide

C2.2 Uranium oxide

C2.3 Graphite based fuels

C2.4 Fuel processing after irradiation

C3. Materials

C3.1 Zirconium alloys:

C3.1.1 Hydrogen migration and morphology

C3.1.2* Ozhennite--a higher temperature alloy

C3.2 Ceramic Materials

C3.2.1 Fabrication

C3.3.3 Engineering of brittle materials

C3.2.3 Properties

C3.3 Fracture and Crack Propagation

C3.4 Non-destructive testing

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C4. Ecology and Radiation

C4.1 Survey of prairie and Canadian Shield species

C4.2 Biogeochemical cycling in insects

C4.3 Stress mechanisms in small mammals

C4.4 Effects of radiation on hybridization

C5. Study of Reconstituted Membranes

C5.1 Permeability to sodium ions and bactereophage

C5.2 Irradiation effects on phospholipid membranes

C6. Reactor Control

C6.1* Automation of boron concentration control

CASE HISTORIES

C1.2 CONTROL OF IMPURITIES IN ORGANIC COOLANT

A major breakthrough, without which the organic programme would have failed, was the discovery that control of impurities in the coolant was vital not only to the prevention of film formation on heat transfer surfaces but also to the successful use of zirconium alloys in organic media. It was found mandatory that the chlorine concentration in the coolant should be controlled to less than 0.2 ppm and that water should be present in the range 100-200 ppm. The discovery of these effects and the development of methods for purity control required the combined efforts of the chemist, metallurgist and the chemical and mechanical engineer.

C1.4 THE TOXICOLOGY OF ORGANIC COOLANTS

This work has been undertaken at CRNL and WNRE since the adoption of the organic cooled reactor programme by

AECL. The work has enabled the previously approved levels for organic coolant in air and in water to be confirmed and has given rise to other related projects which continue to be studied. The papers relating to this project were published during the period 1965-1968.

C1.5 RADIOLYSIS OF COOLANTS

Studies of molecular species such as those found in organic coolant have not only found application in the nuclear reactor but have given basic understanding of the processes involved in the interactions of ionizing radiation with matter. Several papers have been published and the work continues as a matter of basic scientific interest.

C2.1 URANIUM CARBIDE

Uranium carbide has been developed as a high density fuel for use in organic coolant. Together with Canadian industry WNRE has developed a method for fabricating a fuel element that is cheaper than those available from any other country, and whose behaviour has been demonstrated to a burnup of at least 15,000 MWd/te.

C3.1.2 OZHENNITE

A very important development to emerge from the organic programme has been the zirconium alloy, Ozhennite, which has superior resistance to corrosion and hydriding at higher temperatures than Zircaloy-2, Zircaloy-4 or zirconium-niobium alloys. This alloy, first disclosed by the Russians in 1958 but neglected by them since then, was chosen by WNRE metallurgists for its potential in the organic medium, but tests have subsequently demonstrated that it also possesses

a very significant potential as a fuel cladding material for use at high steam qualities and temperatures at least as high as 450°C. At first Ozhennite was little more than a laboratory curiosity but the combined efforts of metallurgists and engineers have resulted in a product which can be easily fabricated in industry both as fuel cladding and pressure tubes. In-reactor proof tests are now under way in WR-1 and in loops in the Chalk River reactors.

C6.1 REACTIVITY CONTROL

A method has been developed for the automatic control of the concentration of boron added to the WR-1 moderator. This allows better control of reactor power and more efficient fuel utilization, and will find applications in the CANDU reactor type.

POWER PROJECTS

The chief project in the years 1962-67 was the construction and commissioning of the Douglas Point nuclear power station.

The purpose of this project was to test the technical and economic feasibility of employing natural uranium heavy water moderated and cooled reactors as the primary energy source in large electrical power generating stations.

The concept of the plant was based on nuclear and reactor physics data and materials research carried out, in large part, at the Chalk River Nuclear Laboratories.

The prototype station has a net capability of 208.000 kilowatts and went into service in 1967. It took six years to build at a total cost of $89 million. The energy produced is sold to Ontario Hydro at the

same rate Ontario Hydro pays to interconnected utilities for energy.

At the present time the station is being worked up to full, mature operating reliability and efficiency. Its operational performance and characteristics are being studied, and modifications are being made and tested, to guide the evolution of the design. It is achieving the purpose for which it was built and the results are promising.

When the plant's mature operating characteristics are established it will be sold to Ontario Hydro at a price to be negotiated, which will represent approximately the plant's economic worth on the Hydro system. The sale price will defray a large proportion of the capital outlay.

The Company's Power Projects organization carried out the design and development of the nuclear steam generating plant for Douglas Point and is doing similar work for the Gentilly station, for Ontario Hydro's Pickering station and for the Rajasthan station for India.

This work entails many detail development projects; 570 such projects have been carried out or are currently in process. Typical examples are:

Douglas Point steam generator development

Reactor control by poison injection

Electrochemical effects on pump seals

Heat exchanger tubesheet development

Stainless steel tube fitting tests

Discharge rates of high enthalpy water from pipes

Protective clothing for radioactive areas

Endurance testing of bellows seal valves

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Enthalpy change in D_2O

Controlled freezing of large diameter pipes

Pickering reactor building relief valve

Ion exchange resin transport in pipes

- as a slurry
- dry, using compressed air

Remote manipulator for fuelling machine vault use

Reactivity control by neutron absorbing fluid (zone control)

Electromagnetic flowmeter

Douglas Point booster rods

Pickering adjuster and shutoff rods

Gentilly booster rods

Primary pump testing - Douglas Point

- Pickering
- Gentilly

Radiation resistance of elastomers

Radiation resistance of lubricants

Plasma arc pipe welding

Case histories are offered of four other examples of detail development projects:

1. On-load fuelling machines for power reactors
2. Mechanical shaft seals for pumps
3. Automatic tube welder
4. A steam Compressor

CASE HISTORIES

FUELLING MACHINES

To permit uninterrupted power production from Canadian

nuclear power reactors it was necessary to design and develop equipment that would change reactor fuel with the reactor operating at a temperature of approximately 550°F and at a pressure of 1,400 pounds per square inch.

The fuelling machines for the Douglas Point nuclear power station and their control systems were designed by AECL Power Projects and were manufactured by Standard Modern Tool Co. The prototype mechanical equipment and the control system were installed in the Power Projects laboratory and underwent extensive testing and development. Modifications, where necessary, were made by the manufacturer if they involved a significant amount of rework, or by AECL laboratory shops in the case of minor changes.

The prototype fuelling machine, controls, testing facility and modifications cost approximately $2 million and involved Canadian industry and AECL staff for approximately six years.

Three fuelling machines for Douglas Point and four for a similar station in India have been based on the prototype, and the fuelling machines for the Pickering station are larger versions derived from the same design.

ELLIPTICAL SHAFT SEALS FOR CENTRIFUGAL PUMPS

Dependable pumps are a necessity on high temperature-high pressure water circuits of power reactors. Leakage at the pump glands must be low and mechanical shaft seals are used to meet this requirement. However, mechanical shaft seal

failures resulting in large leakage rates have caused many pump outages.

Early in the Douglas Point programme AECL development laboratory personnel found it necessary to start a seal design-development program due to the high failure rate of mechanical shaft seals on the test loop pumps. The normal mechanical shaft seal is composed of two circular rings, rectangular in cross section, with rubbing contact between one end face on each. One ring is stationary and sealed to the pump case, the other ring rotates with, and is sealed to, the pump shaft. This latter ring is spring loaded to maintain face contact with the stationary member. The failures on this type of seal appeared to be occurring due to overheating of the rubbing faces, which in turn could be attributed to a lack of lubrication, which of necessity must be by the water being pumped. Laboratory personnel designed and had manufactured one of the circular seal rings with the end contact surface machined to provide an elliptical contact surface. The sealing surface on the mating circular ring is exposed to the water over much of the contact width each revolution and in this way it is lubricated and cooled.

This type of seal was installed in the Power Projects test loop pumps where it has performed well. Seal failures on the primary pumps of the NPD reactor at Rolphton were causing concern so the same AECL personnel designed and had manufactured elliptical shaft seals for some of these pumps. These seals have also performed well.

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AECL holds the patent on the elliptical seal and has arranged with Champlain Power Products Ltd. to sell seals to the pump industry in general. This same manufacturer has produced elliptical seals for the Pickering primary pumps and a set of the seals has al so been manufactured for the Douglas Point pumps.

AUTOMATIC TUBE WELDER

In nuclear power stations there is a great deal of metal tubing in sizes from one-quarter to three-quarters of an inch in diameter. It is usual to connect tubing using mechanical tube fittings. However, very few types of tube fitting meet the acceptable levels of leak tightness and safety and those that do meet the requirements are quite expensive.

To minimize leakage and tube fitting costs, it was decided to weld tubing joints wherever possible. The first AECL automatic tube welder for development purposes was made by John Inglis Ltd. to Power Projects requirements. Further testing and development was carried on between AECL and the manufacturer until the unit was acceptable for site use. Three automatic welding heads and two power supplies were provided for use at Douglas Point and several thousand tubing joints were made with them.

Further development work has been done by the AECL Sheridan Park laboratory and improved tube welders, based on this development, have been purchased from Master Mechanical Manufacturing Co. for Ontario Hydro Pickering station.

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STEAM COMPRESSOR

The decision to design and build a boiling light water reactor (Gentilly) led to a requirement for the Power Projects development division to find a fairly efficient way of simulating the boiling in the reactor coolant channels. This required steam and water to be delivered to the fuel test sites in separate supply pipes and fed into the fuel test channels in the required ratio.

The most efficient way to deliver the steam was by pumping it, and a centrifugal type steam compressor appeared to be the most logical method. However, no steam compressor of the size needed had ever been built.

A contract was placed with Hawker Siddeley Ltd. for the design and manufacture of the compressor. This unit has a capacity of 38,000 pounds of steam per hour at a differential pressure of 300 pounds per square inch. The casing design pressure is 1,600 pounds per square inch. The unit is driven by a 1,000 horsepower, 3,600 RPM electric motor.

The production of a prototype of this kind is a development project and considerable trial, modification and reconstruction are entailed before a satisfactory operating unit is achieved. This development work was carried out jointly by the Power Projects laboratory and the manufacturer.

COMMERCIAL PRODUCTS

The major part of the work undertaken can be classed as development, the remainder being applied research. Over the period 1962-1967 sets of projects were carried out in the following programme areas.

1962-63	1)	Gamma Irradiation Development
	2)	Radiotherapy Development
	3)	Food and Drug Irradiation
	4)	Isotope Process Development
	5)	Instrument Development
	6)	Neutron Source Development
	7)	Radiation Chemistry Research
1963-64	-	same as 1962-63
1964-65	-	same as 1962-63, less No. 6
1965-66	1)	Gamma Irradiation Development
	2)	Medical Applications Development
	3)	Food Irradiation
	4)	Isotope Process Development
	5)	Nuclear Instrumentation Development
	6)	Radiation Chemistry Research
1966-67	-	same as 1965-66, plus Neutron Applications
1967-68	-	same as 1966-67, plus Isotope Power Sources

CASE HISTORIES

POTATO IRRADIATION

Research and development on the inhibition of sprouting in potatoes by treatment of the harvested crop with gamma rays was undertaken in the late 1950s and terminated in 1964. The work involved studying chemical organoleptic, cooking, nutritional

characteristics and storage effects in irradiated potatoes as a function of gamma dose.

Information from these studies, in conjunction with information from Russia, the United States, France and Britain, was utilized in a petition to the Food and Drug Directorate, resulting in clearance to market irradiated potatoes (the western world's first clearance of an irradiated food). Parallel work was conducted on the physics, engineering and economics of the process, and the world's first mobile process irradiator, a 50-ton, truck-mounted unit with a Cobalt-60 source, was built to demonstrate the process to industry.

To date, however, no existing company has utilized the process commercially. One company was formed to store and market potatoes and an irradiator was built for them to apply the sprout inhibition process. This company failed in the first year because of a very poor crop and inexperienced management. In spite of this, the process is still considered to be technically and economically sound. Other countries have followed Canada in approving it from a health point of view, but no other commercial use has been attempted in the western world.

Nevertheless, it is felt that this and similar processes will eventually find commercial applications in Canada and elsewhere. However, it may be necessary to go farther in supporting their introduction to the commercial market.

The experience and recognition gained in developing this industrial application of gamma irradiation subsequently enabled CP to design and build the first two medical products sterilization facilities in North America, and led to establishing CP as one of the world's leading suppliers of research and industrial irradiators.

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AERIAL SURVEY FOR URANIUM AND THORIUM

While this project is not a direct application of radioisotopes, it is an interesting example of technical competence built up for one purpose being also applied for another purpose. The experience gained in developing instrumentation for the industrial use of radioisotopes has been successfully applied to the development of radiation detection and analysis systems for aerial exploration for uranium and thorium. The first system was developed for the Department of Energy, Mines and Resources, and was successfully flight tested in 1967. Flight data is recorded on magnetic tape and later analyzed on a ground based computer. Future improvements will include airborne computers for immediate data analysis. CP was responsible for all aspects of development, design, construction and testing, and worked effectively to create a system in the shortest possible time.,

RADIOISOTOPE TRACING IN WOOD CHIP DIGESTERS

A standard technique has been developed and applied to the study of wood chip movements in the large (75 to 250-foot-high) digesters used by the pulp and paper industry. Radioactive Lanthanum 140 is placed in a simulated wood chip at the input end of a digester and its progress through the process is followed by a series of radiation detectors placed on the surface of the digester.

The results are being used to help formulate mathematical models of the process for computer studies and computer process control. This method has been used by CP in Canada and the United States. Most of the development work on the method has been accomplished by experienced researchers working in the field under production conditions, backed up by instrumentation laboratories in Ottawa.

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PROCESSED ISOTOPE DEVELOPMENT

The following history of Processed Isotope Development is offered as an example of the kind of scientific activity that was prominent in Commercial Products in the past 10-15 years.

After completion in the early 1950s of work on Polonium 210 and Actinium 227, development of the present complement of 38 isotope products began in earnest in 1959. First came the improvement of Iodine 131 and Sulphur 35 processes and the introduction of a Phosphorus 32 production process by dry chemistry. Then, with the addition in 1961 of Carbon 14, Commercial Products became one of the major suppliers of processed isotopes in North America.

Another ten radioisotopes were added by 1963, the chief among these being Iodine 125 - useful in medical diagnosis. Commercial Products has become the main supplier of this isotope in North America. By the end of 1965 another 21 isotopes of relatively low market volume were added to the product list, as these were simple and cheap to produce. They were added primarily to provide a full complement of processed isotopes consistent with available production capabilities.

Since 1965 Processed Isotope Development has ceased to be a major programme, with only necessary product maintenance being carried out.

Appendix 14

EFFECTS OF OTHER NEW TECHNOLOGIES

Computations

One of the major technological changes brought about by the solid-state era has been the appearance of the comparatively inexpensive digital computer. This is having a revolutionary effect on the science laboratory where more and more it is being introduced as a front-line aid to experimentation. The speed and memory capacity of modern digital computers allows them to carry out calculations that would be quite impossible by desk calculator. In addition, computers make possible new types of experiments in which the computer is used "on-line" both to analyze the data as they are collected and to control the experimental equipment itself.

2. Properly applied, this new tool will bring during the next five years a marked increase in the efficiency of scientific research. It will permit the scientist to screen his results at the earliest possible moment so that if necessary he can change the course of an experiment and steer it more rapidly to a fruitful goal. Equally important, more of the researcher's time will be freed for digesting the implications of his work.

3. However, if the hoped for benefits are to be achieved, this revolution must be guided, and to this end a programme of development work known by the code word SUCCESS (a Scheme for Using a Computer in the Control of Experimental Systems and Set-ups) is now under way at Chalk River. Its plan is to mould these new devices into a system especially suited to a researcher's needs. To make the task manageable, the scheme emphasizes common denominators, and to assure efficiency, it emphasizes reliability and ease of use.

Appendix 15

4. An example of a computer application is computer-aided design. The design of a complex system, e. g., a nuclear power plant, typically involves the solution of a set of coupled equations representing the behaviour of the system; the design parameters are varied until an optimum solution is found. Improvements in the speed of computers both allow more realistic models to be used and permit more exhaustive studies of potential designs. At the same time improvements in programming techniques and in input/output equipment -- especially the development of graphical input-output devices -- improve the co-operation between the designer and the computer, and thus further increase the engineer's productivity.

5. Communications between computers will also grow, since input/output equipment, linked to a central computer by telephone lines, can be located wherever needed. The CDC-6600 computer to be installed at CRNL in January 1969 will be made available to other AECL sites by such links.

6. The use of small special purpose computers in collecting experimental data and performing "on-line" some analysis of the information has been widely developed; approximately 20 such systems are now in use within AECL. The trend now is to extend these systems to control the experimental equipment. Frequently such control decisions will require analysis by a more powerful computer; we therefore intend to continue to develop links between the "on-line" computers and the general purpose central computer.

7. In many types of experiment the central computer will be required to store large quantities of data for long periods of time -- for example, the histories of in-reactor tests of power reactor components.

The computer will then make them available to assist in the evaluation of different materials and designs and in the search for correlations between, for example, radiation and subsequent changes in mechanical properties.

8. Another technological development that is expected to increase the efficiency of AECL's research and development is the mechanization of systems for searching and retrieving the literature of science and technology.

9. Before undertaking a new project of research or development it is necessary to be fully aware of all previous information on the subject, to avoid duplication of work already carried out elsewhere. During the course of a project it is necessary to keep up to date with all new publications relating to the subject of the project. Both of these requirements have become increasingly difficult to satisfy because of the very large quantity of information that has been, and is being, published. It is only by the application of computers to the retrospective searching and selective dissemination of information that scientists and engineers can be provided adequately with past and current information.

10. AECL is exploring the use of the Euratom information system which provides for computerized searching of 700,000 abstracts (increasing by 10,000 a month) in the field of nuclear science. The possibility is being considered of obtaining computer tapes from Euratom for processing on the AECL computers to provide an information service for all Canadians interested in the nuclear science field. At the same time AECL is co-operating with the International Atomic Energy Agency in the development of an international nuclear information system that will provide comprehensive mechanized information services for searching and organizing the world's nuclear science literature.

Appendix 15

11. Some usage, which will be increased in the near future, is being made of several commercial information retrieval and current-awareness services, such as the "Chemical Titles" service operated by Chemical Abstracts, and the Selective Dissemination service operated by the Institute for Scientific Information.

Accelerators and Microscopes

12. Studies in materials science have been enhanced significantly during the past decade by the growing utilization of accelerators and electron microscopes. The prospects for the next five to ten years are that more sophisticated machines will become available and that these will be a vital component in the search for an understanding of the properties of materials. Once understanding has been achieved, then the way should be cleared for the development of metals, ceramics, polymers, etc., with specified properties.

13. Ten years ago the basic tools of the research metallurgist were the optical microscope and the x-ray diffraction machine. Today these have been supplemented and for some materials research even superseded by a variety of electron microscopes and particle accelerators. As the numbers of such machines proliferate and as their complexity and cost grow the need for closer co-operation and a concerted plan among materials laboratories in Canada become apparent.

14. A pertinent example is in the field of high voltage electron microscopy. For several years the standard electron microscope has been designed for an accelerating voltage of 100 kV. Its market price of $50,000 was within the reach of most departments of metallurgy or materials science in Canadian universities and some industrial laboratories as well. Recent advances in high voltage

engineering have made possible the development of 1 MV microscopes, instruments which offer many opportunities for significant research on the structure-sensitive properties of solids and, in biology, to probe living matter. Since the machine cost increases nearly linearly with voltage, it is apparent that only a few million-volt microscopes will be installed in Canada during the next decade.

15. Chalk River offers many advantages as a site for such an instrument because of the concentration of specialists in electron optics, metal physics and biology, for example, and because of the availability of many servicing experts in electronics and high voltage technology. If such an installation were to be made during the next five-to-ten years there would be an associated growth of co-operative endeavours with the universities and with Canadian industry.

16. A similar forecast can be made of the impact of the installation of accelerators for chemistry and materials research at CRNL and WNRE during the next decade. This has been made possible because the base price of a 4 MV accelerator has been brought down to $200,000. Such an accelerator is sought by chemists and materials scientists who are not specialists in nuclear physics. The use of such a tool involves other specialized equipment such as gamma-ray spectrometers and nuclear particle detectors used with high speed coincidence detectors and on-line electronic analysers and recorders. A number of laboratories across Canada where such closely integrated techniques can be brought to bear will link with each other to serve the whole scientific community. Scientists from the smaller laboratories in industry and universities will avail themselves of the facilities of such major institutes.

<u>Appendix 15</u>

First Session—Twenty-eighth Parliament
1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
SPECIAL COMMITTEE
ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*
The Honourable DONALD CAMERON, *Vice-Chairman*

No. 6

THURSDAY, OCTOBER 31st, 1968

WITNESSES:

Eldorado Nuclear Limited: William McKenzie Gilchrist, President; Gordon F. Colborne, Manager, Research and Development Division and Donald David Bell, Staff Engineer.

APPENDIX:

6.—Brief submitted by Eldorado Nuclear Limited.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29103—1

MEMBERS OF THE SPECIAL COMMITTEE ON SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—

The question being put on the motion, it was—

Resolved in the affirmative."

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—
Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

THURSDAY, October 31st, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 11:45 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Grosart, Kinnear, Leonard, MacKenzie, Robichaud and Thompson—10.

Present but not of the Committee: The Honourable Senator Giguère—1.

In attendance:

Philip J. Pocock, Director of Research (*Physical Science*).

The following witnesses were heard:

ELDORADO NUCLEAR LIMITED:

William McKenzie Gilchrist, President.

Gordon F. Colborne, Manager, Research and Development Division.

Donald David Bell, Staff Engineer.

(*A curriculum vitae of each witness follows these Minutes.*)

The following is printed as an Appendix:

6.—Brief submitted by Eldorado Nuclear Limited.

At 12:45 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Gilchrist, William McKenzie. Date of birth, July 29, 1909, Place of birth, Weyburn, Saskatchewan. Armed Forces Service, 1941-1945, Canadian Army Overseas, Staff Captain, Royal Canadian Engineers. Education, Secondary, Saskatchewan and Ontario. University, One year University of Manitoba, Queen's University, Kingston B. Sc. in Mining and Metallurgy 1936. Positions Held, Various mining operations in Manitoba, Quebec, 1936-1939; Preston East Dome Mines Ltd., 1939-1941, Engineering Staff; Efficiency Engineer 1945-1946; Trans American Mining Co. Ltd., 1946-1950, Exploration and Development; Giant Yellowknife Gold Mines Ltd., 1950-1951, Chief Engr. and Underground Supt; Transcontinental Resources Ltd., 1951-1952, Vice President, Manager of Mines Eldorado Nuclear Limited; 1952-1955, Asst. Manager, Beaverlodge Oper.; 1955-1958, Manager, Beaverlodge Oper.; 1958, Vice President, Western Oper.; Vice President, Operations; 1958, Present President of Eldorado Nuclear Limited and of the following subsidiaries. Eldorado Aviation Limited, President; Northern Transportation Company Limited, President. Directorships, Eldorado Nuclear Limited; Northern Transportation Company Limited; Eldorado Aviation Limited; Atomic Energy Control Board; The Mining Association of Canada; Canadian Nuclear Association. Memberships, Advisory Panel on Atomic Energy; Canadian Institute of Mining and Metallurgy; Arctic Institute of North America; Boy Scouts of Canada.

Colborne, Gordon F. Date of birth, March 3, 1924, Place of birth, Sydney, Nova Scotia. Armed Forces Service, 1942-1945, Flying Instructor, RCAF Rank on Discharge, Flying Officer. Education, Secondary, 1937-1940 Nova Scotia Grade XI; 1946 (4 mos) Ontario Grade XII; University, 1946-1950 Queen's University, B. Sc. in Chemical Engineering; 1964-1965 U.B.C.—Post Graduate Metallurgical Studies. Positions Held, Eldorado Nuclear Limited; 1950-1952, Port Hope, Ont., Research Engineer; 1952-1955, Ottawa, Ont., Research Engineer; 1955-1964, Beaverlodge, Sask. Mill Supt.; 1965-1967, Ottawa, Ont., Asst. Manager, Research and Development; 1967, Present, Ottawa, Ont., Manager, Research and Development. Professional Societies, Association of Professional Engineers of the Province of Ontario. Canadian Institute of Mining and Metallurgy.

Bell, Donald David. Date of birth, January 22, 1923, Place of birth, Winnipeg, Manitoba Education, Secondary, Calgary, Alberta; University of Alberta—B.Sc. in Mining Engineering, 1950. Armed Forces Service, 1942-1945, RCAF. Positions Held, Eldorado Nuclear Limited; 1950-1957, Beaverlodge, Sask., Exploration, Mine Supervisor, Chief Planning Engineer; 1958-1952, Ottawa, Ont., Ore Procurement Contracts; 1962-1967, Port Hope, Ont., I/C Ore Procurement Division; 1967, Present, Ottawa, Ont., Staff Engineer. Professional Societies, Association of Professional Engineers of Ontario; Canadian Nuclear Association; Canadian Institute of Mining and Metallurgy.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, October 31, 1968

The Special Committee on Science Policy met this day at 11.45 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, I am pleased to welcome today Mr. William Gilchrist, President of Eldorado Nuclear Limited, and two of his colleagues, Mr. Gordon Colborne and Mr. Donald Bell.

Eldorado Nuclear Limited has been in existence for some time. Its origin dated back to our efforts in the whole nuclear field, and I understand that it was established in 1944.

Senator MacKenzie: Mr. Bennett was in this originally? Is he still associated with the Company?

Mr. William McKenzie Gilchrist, President, Eldorado Nuclear Limited: He is still a director.

The Chairman: Without any further comment I will ask Mr. Gilchrist to make his statement.

Mr. Gilchrist: Honourable senators, I was a bit surprised when I was asked to come here, because our scientific effort compared with what you are dealing with was rather small, but in my case it was indicated to me that before I am finished you are going to question me on uranium. I will now proceed with the formal request. Thank you.

Introduction:

Eldorado Nuclear Limited is a Crown Corporation, incorporated under the Dominion Companies Act. The Company operates under Part VIII of the Financial Administration Act and is listed in Schedule D of that Act as a proprietary corporation which is defined as a corporation which owns its assets and generally conducts its operations without appropriations.

The Company's only mining operation is now carried on at Beaverlodge in northern Saskatchewan, the original mine at Port Radium on Great Bear Lake having been closed in September 1960 after a long and notably successful record in the production of uranium. The Company also owns and operates at Port Hope, Ontario, the only uranium refinery in Canada.

The Research and Development Division of the Company's activities is centered in Tunney's Pasture in Ottawa where a modern and well-equipped laboratory is maintained. The following pages outline the operations of this Division in accordance with the Guide for Submission of Briefs distributed by the Secretary of the Senate Committee on Science Policy.

Summary of Recommendations:

(a) We recommend a greater use of industrial research and development facilities by federal government departments in their long range scientific and technological programmes. These industrial laboratories are usually staffed and supervised by individuals having production experience and are therefore more "cost conscious" in their development work on new processes and products than is sometimes the case in governmental "in house" laboratories. In many instances, industrial research laboratories have access to pilot plant and commercial scale equipment with which to test newly developed processes and products.

(b) Direct financial assistance to industrial research laboratories would be a major factor in the development of the full potential of these units and their subsequent contribution to the total Canadian research effort. These incentives should be based upon total expenditures by the Company rather than only on the annual increase in expenditures as is the case at present.

The Chairman: We will now start with the question period. Senator Robichaud.

Senator Robichaud: Mr. Chairman, we know that Eldorado has played a very important role in the Canadian uranium story and

also that for a limited period of time they were the sole producers of uranium in Canada. On page 1 of your brief, sir, you state that the "Company's only mining operation is now carried on at Beaverlodge in northern Saskatchewan, the original mine at Port Radium on Great Bear Lake having been closed in September 1960..." Was it closed owing to lack of minerals?

Mr. Gilchrist: It was closed due to the exhaustion of the ore bodies, yes.

Senator Robichaud: Due to the exhaustion of the ore bodies, I see.

Mr. Gilchrist: Yes, we actually mined more from the Port Radium mine than was covered by our contracts at that time, but there is nothing left now that could be economically exploited.

Senator Leonard: That was the original discovery, was it not?

Mr. Gilchrist: That was the original uranium discovery in Canada, yes.

Senator Leonard: What are the possibilities now? Do you have ore bodies that will last for many years?

Mr. Gilchrist: At our present rate of production at Beaverlodge now we have a firm ore reserve for between 11 and 12 years, and, looking at the experience of the past 15 years, I am fairly confident that we have 15 years operation ahead of us.

Senator MacKenzie: Is Elliot Lake still producing uranium?

Mr. Gilchrist: Oh, yes. There are three mines there. There are three companies actually producing—Denison, Rio Algom and Stanrock.

Senator MacKenzie: They are private operations, are they? They are not under you?

Mr. Gilchrist: They are private, yes.

Senator MacKenzie: Do they refine at Port Hope?

Mr. Gilchrist: What refining they require to be done at the moment is being done at Port Hope.

Senator MacKenzie: And do they sell direct?

Mr. Gilchrist: They sell direct to customers, yes.

Senator MacKenzie: To customers anywhere?

Mr. Gilchrist: That is right.

Senator MacKenzie: Is there a control over the sale of uranium?

Mr. Gilchrist: Only from the viewpoint of the Atomic Energy Control Board, which administers the Atomic Energy Control Act and which is largely responsible for making certain that the safeguards policy of the Canadian Government is administered.

Senator MacKenzie: Has that to do with the peaceful uses of uranium?

Mr. Gilchrist: That is correct.

Senator Bourget: Are you making any exploration in other areas to find any other mines? Have you got an exploration branch?

Mr. Gilchrist: We have only been allowed to go back into exploration this year. I believe it was in July of this year. I am speaking now of general exploration and not of our own properties. We have been developing our own properties over the years. Originally, Eldorado was the only company that was allowed to look for uranium. I am going back to the 1940's when I say that. In the 1950's it was thrown open. In 1957 we went out of exploration for a while, but came back in 1958 owing to the closing of Port Radium. We decided that we should make an effort to keep the area alive. At that time the Port Radium mine was the only commercial activity in the area. We went back into exploration on the understanding that we would confine our efforts to the Northwest Territories and the Great Bear Lake area. After two years the Government in power decided that we should cease our outside exploration. However, we continued exploring the properties that we owned or had under our control, with the result that we are now bringing in a small satellite mine at Beaverlodge and have extended the ore reserves of the parent mine considerably.

Early this year it was decided, owing to the coming demand and the current interest in developing uranium reserves, that we should not be locked in, that the knowledge and capabilities of our staff should be allowed to range a little wider than as merely required by our own properties. So we now have permission to re-enter general exploration. We have not done much this year due to

the fact that it takes time to expand the staff and to actually decide on a program. Where do you want to go? What to you want to do? How extensive will it be?

We also have permission to enter into partnership with commercial companies in exploration. In other words, if certain companies have property that they would like us to examine for them by ourselves or on a joint basis, or in whatever way they want to work it out, we have that permission now.

Senator MacKenzie: Does Africa still produce much uranium?

Mr. Gilchrist: Oh, yes. They are producing roughly about 3,600 to 4,000 tons.

Senator MacKenzie: What percentage of the world's production do we have?

Mr. Gilchrist: Do you mean the current percentage of the world's production or fo the world's reserves? I will answer both, and when I refer to the world I mean the western world. I am not speaking of the Communists.

Senator MacKenzie: I realize that.

Mr. Gilchrist: The western world will produce something like 24,000 tons this year. That is actual concentrate. Of that Canada will produce about 4,000. That is roughly one-sixth. South Africa will produce perhaps a little less than that, but that is about it. Now, that is current production. As to reserves, there are about 600,000 tons of reserves in the world today that can be produced at a price less than $10. This matter of price is rather important. We have about one-third of that amount, in other words, about 200,000. South Africa has somewhat less than that. They have about 150,000 or so. Again, I am speaking of 08 or $10, although they have upped them somewhat just recently. They say about 205,000.

The 600,000 figure that I gave you is the igure of about a year ago. They now say that erhaps there is as much as 800,000 tons in he world that can be produced under $10. But some of the other 200,000 I think has to e confirmed yet. Certainly, however, there re 600,000 tons.

The Chairman: Could you give us the gures for other countries, such as the United tates?

Mr. Gilchrist: Speaking roughly, the United tates have approximately 300,000 tons that ey claim can be produced under $10. If you go down to the $8 figure, then that drops to somewhere around 150,000 tons.

When you ask these questions on reserves, you immediately get into this matter of price, and it is difficult, actually. If you want to go on up to $15 or $20, you can double or treble the reserves.

Senator Bourget: In those joint ventures you have with private industry, do you use your own staff or do you help only to finance the projects?

Mr. Gilchrist: At the moment we haven't any joint ventures going, but we have permission to enter into joint ventures this year. So far we have not joined any. However, the permutations and combinations on a venture of that kind would be almost infinite. From our point of view the trend may be that we will contribute the expertise and, hopefully, the other partner will contribute the finances. In other words, we will be selling our knowledge of the problem.

Senator Thompson: Following on that question, assuming you do strike uranium with a joint exploration project outside of the territory owned by the private industry, what arrangements follow from there?

Mr. Gilchrist: You mean who would own the production or who would benefit?

Senator Thompson: Yes.

Mr. Gilchrist: Again it would depend on what basic arrangements were entered into in the first place. They can change as development takes place. You may have a 50-50 arrangement regarding exploration—that is where you are putting up 50 per cent of the cost and your partner is putting up the other 50 per cent. But then the next step would be development. At that point you may say "Well, we haven't got the necessary financial backing or the resources," and the partner may at this point take on 75 per cent of the cost. Then you can get to the point where you are actually going into production and you need millions of dollars to do that. Then again you must sit down and negotiate the matter depending entirely on the percentages of the financial backing available. That is basically what it will be made up of—how much of the actual money required you will be able to guarantee to put up. I could not tell you at this particular moment; I could give you lots of, shall we say, framework, in which it could be done, but what would be

demanded by any particular set of circumstances is something that could not be decided until the circumstances were all clear.

Senator Robichaud: On page 13 of the brief referring to R & D projects on non-nuclear materials, you state:

> Extensive testwork was carried out in 1963, 1964 and 1965 on methods of recovering cobalt, nickel, copper and silver from a wide variety of residues, ores and concentrates.

But further on you state that the market and economic conditions at that particular time were not favourable for the construction of a commercial operation. What is the situation now? Has it improved since 1965 or is it the same?

Mr. Gilchrist: Regarding these particular metal elements, no. We are not really interested in them any more. I might explain that this was brought about due to the fact that the activity at the refinery had subsided due to the dropping off in the production of uranium. We were then faced with an organization that could, shall we say, just disappear if we closed the operation down, so during those years we made quite an effort to see whether the systems and processes that we had developed in connection with the refining of uranium could be used in the production of other metals. We found they could, but at the time it just wasn't economic. We could have produced the metals, and we could perhaps have made an operating profit, but the capital involved and the return we would get on our capital would not warrant any further investigation or any further financial investment. It was really an effort to try to keep the Eldorado refinery in existence, because we knew that eventually it would become quite an asset.

Senator Robichaud: Mr. Chairman, in the Annual Report of Eldorado Mining and Refining Limited I notice the balance as of the 31st December 1967 was $1,118,630 which is to be offset in the period 1968-1971 when deliveries will be made at prices which are lower than the costs of acquisitions. Can we get any explanation of this?

Mr. Gilchrist: You mean why are we selling at what would seem to be less than cost?

Senator Robichaud: Yes.

Mr. Gilchrist: This is the problem the uranium industry in Canada is facing at the moment. We are continuing to try to keep our reserves in existence. But the price at the moment is actually such that it really doesn't warrant the production of uranium. But as you will notice there is another item here, actually by the Auditor General, that most of this material that was produced went into inventory at a lower price than all of the actual operating costs, due to the fact that this came from the close-down of the Port Radium mine. There is another point in this as well; as you will notice from the financial statements, particularly No. 3, there is another facet here that Mr. Bell has pointed out. In our dealings with the United Kingdom there is a balance coming; although it may appear we are selling for less in this particular case, it will in the end balance out. But if you want to take a straight comparison, your question is very well warranted. But there are reasons for it. We are not actually losing money. We may be doing so before we are through with this, or before the next year or so where, if we require cash, we might have to sell, shall we say, below our actual cost. However, we won't be out of pocket as far as cash is concerned. We will be out of pocket in depreciation and things of this nature. We won't be showing a book profit.

Senator Robichaud: Coming back to research, is the company satisfied it has the best methods available to extract the uranium, and more particularly is the company well informed of the new method which apparently produced what they call "enriched uranium" which the Dutch seem to have found recently? Is the company aware of this system?

Mr. Gilchrist: Yes. But I think you must have clearly in mind here what the difference is between uranium and enriched uranium. Uranium, as it occurs in nature, usually as the compound U_3O_8, contains about seven-tenths of one per cent of the fissionable isotope U235. The remaining 99.3 per cent is made up of the non-fissionable isotope U238. The enrichment process is designed to increase the percentage of the U235 isotope in the mass.

In the United States, Britain and France, the gaseous diffusion process is used for enrichment. It consists of a very large number of stages in which the heavier U235 atoms, because of their larger size, diffuse through a membrane at a slower rate than the lighter U235 atoms. This results in an

upgrading of U235 on the other side of the membrane.

By the centrifuge method you spin the uranium in small units and the heavier isotope is concentrated at the outside. They hoped at one time that this would be a much better method of doing this. It may well be, but the technical problems involved in this are quite large. With the peripheral speeds of 800-1,000 meters/sec faster than the speed of a bullet, you can imagine the technical problems you have in this thing with bearings, and so forth.

It is a fond thought on the part of many of the smaller countries who have not the financial capability required for an enrichment plant, that you could have a very small unit, or a small number of these small units or cylinders spinning, and that they could produce their own enriched material. But, as yet, no one has economically, overcome the technical problems of the actual operation.

Senator Aird: I think your answer is very germane. I suppose you were not here yesterday, Mr. Gilchrist, when the AECL was testifying, but they did indicate some interest in building an enrichment plant in Canada. Do you have a comment on that? I also understand that research on this has been banned in the United States.

Mr. Gilchrist: Yes, there has been an agreement in the States, when this centrifuge thing came in some years ago, that this would not be pursued, except within their own boundaries. I know the Dutch have been carrying on centrifuge research for a number of years. But there was a gentlemen's agreement to the effect that they would not dissipate any of this information—but what I have given you is common knowledge.

There is an interest in the development of an enrichment plant or facility in Canada, due to our reserves and so forth. I was on the committee of the Canadian Nuclear Association that looked at this problem, and we publicly stated we did not think that the Canadians should undertake this at the moment; even though we have a large uranium and power reserve. Canada should not do it on their own because of the number of dollars involved, and in view of the small numbers of people the plant would employ. We could use our money to greater advantage for the Canadian public elsewhere. A diffusion plant would take upwards of $1 billion to build even as a modest program, and that would not take care of all the possible Canadian uranium production.

I do not think there is any company in Canada that would want to take this on. There will have to be additional enrichment capacity in the world by 1975 to 1978, so someone has to build additional capacity.

A number of the large companies—such as Westinghouse, General Electric etc.—have been looking at this problem, and one of the things that immediately came to light is the vast quantities of power that are required for the process. Of course, we still have undeveloped water power in this country, and this could be used, but I would strongly recommend and anyway support the view that Canada does not take on the full responsibility. If you could get someone outside the Government to look after the plant, then maybe you could supply the power which Canada has. Favourable power rates are one of the things that make the building of this type of plant in Canada an attractive and feasible possibility.

Senator Aird: Are you actively seeking out partners for this?

Mr. Gilchrist: We are not, no.

Senator Aird: Is it a fair question to ask if AECL is?

Mr. Gilchrist: I do not think so. I think there have been conversations held with some of the departments by the larger U.S. companies, but they are very tentative and I would not like to be specific at the moment.

Senator Bourget: Who owns the enrichment plant in the United States at the moment? Is it a government agency or a private company?

Mr. Gilchrist: It is owned by the Government. This was brought about due to the efforts made in connection with defence. These plants were partially written off against the development of the atomic bomb and the defence program. I cannot say that definitely, but I think that is pretty well what happened.

Senator MacKenzie: Mr. Chairman, at page 3 of the Annual Report there is a statement of all-Canada uranium sales. In 1959 the other producers sold close to $300 million worth. Was this for stock-pilling? I as that, because the total sales are now down to $27 million.

Mr. Gilchrist: Well, when you say "stock-piling" we shall have to qualify it. You see,

our contracts originally were with the United Statees and the United Kingdom. They were with the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority. What we were shipping in 1959, with the exception of a very small percentage, went to these two organizations which, in turn, were either turning the material into bombs, or stock-piling it. We have no knowledge as to what they did with it once it went to their plants. We do not know whether it went into a stock-pile or into a bomb, but was for the defence effort. A very small part of it went to the development of the nuclear power reactor, but the quantity required at that time for the nuclear power program was relatively small.

Senator Bourget: In that table you state that Canada's uranium sales—is it only uranium that is sold by your organization, or does it include also uranium sold by other companies such as Denison and Rio Algom?

Mr. Gilchrist: This is Canada's sales for USAEC and UKAEA contracts, what has been sold by everybody. That is the total sales.

I should give you a bit of background on that. In the original arrangement Eldorado was designated as the Canadian agent in matters concerning uranium, and at that time all sales were to the U.S. Atomic Energy Commission and the UK Atomic Energy Authority. Under those original contracts Eldorado wrote a contract with the producing Canadian companies and also wrote an identical contract with the United Kingdom and the United States. The producers sold to Eldorado, and we immediately sold to the United States or the United Kingdom. We had no stock-pile. It was deemed at that time to be more to the advantage of all concerned for the producers to have one voice or one agency dealing with these government organizations.

Since that time, and when the power utilities began to build reactors, it has been decided that it would be better for the utilities to deal directly with the producers, and this is what is happening now. All that Eldorado is administering now with regard to uranium is the remnants of the contracts we had with the United Kingdom Authority and the Canadian stock-pile program. In the case of the United Kingdom contract, we hold the only remaining contracts which is with Rio Algom, and we have an identical contract, or a very nearly identical contract, with the United Kingdom Atomic Energy Authority. The last deliveries under that contract will be made in about 1971, I think.

Now, as far as the stock-pile is concerned, Eldorado acts as the Government agent only in administering the contracts that the producers have with the Government or, to be specific the Ministry of Energy, Mines and Resources. So far as the utilities are concerned, it is now an open market.

Senator Bourget: And that is what happened in the case of the sale that was made to those two companies that I have mentioned, when we sold 10 million pounds—is that correct?—to Japan?

Mr. Gilchrist: Yes, this is what happened. They negotiated their own contract.

Senator Bourget: You had nothing to do with it?

Mr. Gilchrist: We had nothing to do with it whatsoever.

Senator Bourget: Coming back to research, have you any association, or are you working closely, with the private companies that are also doing research in this field?

Mr. Gilchrist: They have been conducting really very little research. The actual producers have asked for assistance from time to time, although not in any great amount because they have not extensive research facilities of their own.

Senator Bourget: By this you mean that the private industry has not been doing much in the way of research up to now?

Mr. Gilchrist: Over the last four or five years they have not been doing too much due to the fact that they were really involved in staying alive over that period of time during which there was no great demand for uranium. They had contracts at prices that were not, perhaps, too profitable. So, the amount that was being spent by private industry in connection, shall we say, with basic or pure research was not very much.

Senator MacKenzie: What was the outcome of the controversial discussions with France about the sale of uranium? Did that go through?

Mr. Gilchrist: No, the sale was not consummated.

Senator MacKenzie: This was on the issue of peaceful uses?

Mr. Gilchrist: That is correct, yes.

Senator Thompson: As a Crown corporation I presume you would set the highest standards of safety and technical approaches which perhaps others should adopt. I recall that there was quite a fuss about the disposal of waste at your Port Hope plant. Are you satisfied that the public are protected sufficiently by your present method of waste disposal?

Mr. Gilchrist: Oh, yes. I think the people who actually had some questions were completely satisfied by the time we were through. Mind you, this did not hurt us from the public point of view because we have actually increased our safety precautions, or, at least, we have added certain procedures that make our operation even safer than it was before. But, there was really no argument once you knew what was involved, and the public were in no way endangered by the situation that existed before.

We had put up signs around the waste disposal area and after three or four years during which time they were used for target practice by boys with their .22's, and things like that, the signs were in a sorry state. Perhaps they were not changed as often as they should have been. Also, the level of the lake dropped a little and the water's edge receded beyond the end of the fence, affording an access route to the area. This has been corrected.

We have also made certain that there is no seepage into the lake. The amount of seepage hat previously had access into the lake was of little consequence—they admitted this—but ve have now made certain that nothing gets nto the lake.

Senator Thompson: Is this being translated nto regulations by other provincial governnents or the federal Government that apply o mining operations?

Mr. Gilchrist: No.

Senator Thompson: So, there are gaps then, n that respect?

Mr. Gilchrist: I would not say "gaps," ecause to lay down regulations that would ok after all circumstances in this developing ld would be somewhat impracticable. In ct, it would lead to inconvenience and nnecessary red tape, if you will. In many ses, you are trying to forecast certain conions, and right at this moment you are trying to lay down rules to look after something that may never happen. The Atomic Energy Control Board, which will be appearing before you, of which I happen to be a member, has this very much in mind.

The problem is to develop a practical set of regulations, and as the problem develops industry is trying to keep abreast. Of course, you have provincial and federal jurisdiction in this matter. To date I think it has been covered fairly well. The Atomic Energy Control Act gives the board wide powers. It is again a continuing problem of developing something that is adequate yet not inhibiting as far as the commercial business is concerned. To date I think this has been fairly well done.

We have had this waste disposal problem, which did not really develop into a problem. There has also been the problem of increased radioactivity in certain lakes, from mill tailings or the level of radioactivity in the waters. Again, this was not too serious but it is something that has to be watched very closely. With the surveillance it is now getting, largely by provincial authorities with the support and advice of the board and its officers, I think we have the problem pretty well under control.

Senator Grosart: Mr. Gilchrist, will the very substantial increases coming in the price of nuclear fuel adversely affect the cost advantage in fuel now enjoyed by the AECL natural uranium heavy water reactor system, compared with comparative systems?

Mr. Gilchrist: No. The reverse should be what will happen. In other words, it should give the natural uranium system an added advantage. But it will not be large because the percentage of the total cost attributable to your uranium is relatively small. In the Canadian system it is roughly about 3 per cent at $8 uranium. Speaking now of the lower capital costing enriched nuclear power reactor in the United States, it is about 6.2 per cent or something of that nature. Therefore, the amount of percentage increase in costs that could be attributable, say, to a dollar per pound increase in uranium is relatively small. I think it would be to the advantage of the natural uranium system rather than to its disadvantage because the natural uranium system is much more efficient in its use of basic fuel.

Senator Grosart: Does the Canadian system burn up more or less fuel than the American system?

Mr. Gilchrist: Relatively less.

The Chairman: That is why the cost of operation is lower.

Senator MacKenzie: Did Gilbert Labine make some of the original discoveries in the north?

Mr. Gilchrist: Yes. He discovered the Port Radium mine.

Senator MacKenzie: What date was that? Was that in the thirties?

Mr. Gilchrist: That was in 1930, I think. Originally I believe he was prospecting in the area in 1929, or made a preliminary trip into that area. However, it was 1930 before he located this cobalt bloom.

Senator MacKenzie: I was going to say, this was rather accidental, was it not?

Mr. Gilchrist: It was, yes, because he was directed to the area by reading a report written by Dr. Camsell and Dr. Mackintosh Bell of the trip they had made in 1900, when they reported signs of cobalt bloom on the shores of Great Bear Lake. Cobalt generally occurs in close mineralogical association with silver. It was that report that pulled him into the area in the first place. He was quite knowledgeable, of course, in minerals and he recognized the mineral pitchblende which occurred with the cobalt and silver. He had read extensively in Madame Curie's book about pitchblende, and due to that knowledge and his powers of observation he realized the importance of this find. It was quite a spectacular find. There was exposed on surface a vein of pitchblende almost 15-20 feet wide. I doubt if there will ever be another one like it in Canada, or even in the world as far as that is concerned.

Senator Thompson: Is there any long-term medical examination of men working in the mines?

Mr. Gilchrist: Yes. This is something on which we have an extensive program. The miners are examined once a year. For instance, anyone in the canning or packaging section for concentrates of the final product is examined weekly. On the surface the only problem is with those people who are directly connected with packaging the final product. Underground there is a problem from the release of radon gas, which breaks down very quickly into several products, which can be deposited in the bronchial tubes of the lung and lead to cancer. By adequate ventilation, which sweeps this gas out the danger is almost completely eliminated. There are very strict government and in-house regulations and we are attempting to keep it down to a half of one working level. One working level is what a man can continue to work in without any injurious effects. There is a lot of argument about that, but I will not get into it.

The Chairman: If there are further questions, we could ask Mr. Gilchrist to come back in the afternoon. Apparently there are none. On behalf of the committee, gentlemen, I thank you very much for a most interesting presentation.

The committee adjourned.

APPENDIX 6

BRIEF

TO THE

SENATE SPECIAL COMMITTEE ON SCIENCE POLICY

BY

ELDORADO NUCLEAR LIMITED

151 Slater Street
Ottawa, Ontario

1. Organization

1.1 The Research and Development Division of Eldorado Nuclear Limited is set up as a separate Division of the Company, with the Manager of R & D reporting directly to the President.

2. Objectives

2.1 The major objectives of the R & D Division are as follows:

a. to provide research, development and analytical facilities for the investigation of problems and the increase in efficiencies of any of the Company's current processes or products; and

b. to provide for Company expansion by the investigation of new processes or the application of existing processes to new products which could be of economic interest to the Company.

2.2 Two minor objectives of the R & D Division are, first, to act as a training ground for future operating personnel in the Company's production groups and, secondly, to generate income by the sale of research services in areas of the Division's competence.

3. Research Policy

3.1 Overall research policy is determined by a Corporate Research Committee composed of the President, the Manager of the R & D Division, the heads of the two Company operating Divisions and the Company's Metallurgical Consultant.

4. Powers and Functions

4.1 Within the framework of the general policies established by the Research Committee, the R & D Division allocates its resources to the programmes in accordance with the overall Division objectives.

Eldorado Brief to Senate Committee

4.2 The selection of projects related to existing Company processes or products may be made at the request of the operating Division concerned, or may be initiated by the R & D Division itself when a specific process or product is considered to be in need of improvement.

4.3 The level of support of university research in areas of specific interest to the Company is determined within the R & D Division and approved by the Directors of the Company as a portion of the total operating costs of the R & D Division.

4.4 The R & D Division accepts contracts for the performance of research work in any field of competence provided such work does not conflict with internal Company programmes or necessitate the release of Company confidential information.

5. Personnel Policies

5.1 The R & D Division has no fixed establishment of numbers and qualifications of research personnel. The optimum size of the Division will vary, in a two to five year period, with the number and complexity of the current and planned research programmes.

5.2 The identification and procurement of effective researchers from the university graduating classes has been greatly enhanced by the Division's close contact with the university metallurgical departments through the medium of university research contracts.

5.3 In a small research group, such as the R & D Division, no unique criteria are necessary to help identify those who will be creative and effective researchers or those with high potentiality as research administrators.

Eldorado Brief to Senate Committee

5.4 The major distinctions between administrators of research and researchers as such, regarding promotion, is that a definite establishment exists for administrators and promotion cannot occur without a vacancy; whereas researchers may be promoted to the highest categories on evidence of competence. In general, salaries of administrators are higher than those of researchers.

5.5 The R & D Division has a very liberal policy regarding both intramural and extramural education for staff members and each case is judged on its own merits. In general, the Division has assisted graduates with a bachelor's degree who wish to return to university for advanced degrees by carrying them on the payroll at half salary while in full-time attendance at university, paying part of the university fees and providing full-time employment during the summer vacation period. Non-degree personnel or technicians have been assisted in their efforts at self-improvement through completion of high school at night classes, studies at technological institutes or by taking specific university courses. Company assistance in these cases has involved time off from work with pay, payment of course fees and promotion or salary increase on completion of specific programmes. Research administrators are usually sent to management courses at universities or management training centres on Company time and at Company expense.

6. Personnel Associated with Scientific Activities

6.1 Current Personnel Establishment

Professional Staff	18
Technicians	28
Clerical & secretarial	5
	51

Eldorado Brief to Senate Committee

6.2 Number of above professional staff devoting most of their time to administrative duties = 3.

6.3 Statistics of Professional Staff

Degree Category	Country of Birth	Country of Secondary Eduction	Country of University Degree	No. of Years Since Grad'n	No. of Years With Eldorado	Age	Capability in French and English
B.Sc.	Canada	Canada	Canada	18	18	44	English only
	Canada	Canada	Canada	24	20	47	English only
	Canada	Canada	Canada	17	13	41	English only
	Canada	Canada	Canada	17	14	41	English only
	Canada	Canada	Canada	19	16	44	English only
	England	England	England	8	1	30	English and French
	Hungary	Hungary	Hungary	15	4	42	English only
	England	England	England	12	6	34	English only
	Canada	Canada	Canada	2	1	26	English and French
	Scotland	Canada	Canada	1	1	25	English only
M.Sc.	Canada	Canada	Canada	28-BSc 20-MSc	20	49	English only
	Canada	Canada	Canada	20-BSc 1-MSc	16	42	English only
	Canada	Canada	Canada USA	21-BSc 20-MSc	14	45	English only
	Canada	Canada	Canada	15-BSc 13-MSc	6	42	English only
	England	England	Canada	3-BSc 1-MSc	11	39	English only
	Canada	Canada	Canada	4-BSc 3-MSc	1	27	English only
	Canada	Canada	Canada England	39-BSc 28-D.I.C.	6	63	English only
Ph.D.	Poland	India Africa Canada	Canada Canada Italy	12-BSc 10-MSc 5-D.Chem.	4	34	English only

The percentage of bilingual professionals is 11%.

6.4 Numbers of Professional Staff in Categories by Years

		B.Sc.	M.Sc.	Ph.D.
Actual	1962	14	1	1
	1963	13	5	0
	1964	17	5	2
	1965	13	5	1
	1966	11	4	1
	1967	11	5	1
	1968	10	7	1
Estimated	1969	10	7	2
	1970	10	6	3
	1971	11	6	3
	1972	11	7	3
	1973	11	7	3

6.5 Percentage Turnover of Professional Staff

	B.Sc.	M.Sc.	Ph.D.
1962	29	-	100
1963	-	-	100
1964	30	-	200
1965	15	20	-
1966	9	-	-
1967	27	-	-

6.6 The percentage of current professional staff who, since graduation, have had outside experience is as follows:

a. Percentage employed in industry 89%

b. Percentage on university staffs 17%

c. Percentage on provincial government staff nil

d. Percentage on federal government staff 33%

6.7 Staff on Education Leave

At the present time the R & D Division has one professional on education leave. He has obtained both his B.Sc. and M.Sc. with Company assistance and is presently working toward a Ph.D.

6.8 Summer Employment for University Students

Year	No. of Students
1962	4
1963	6
1964	6
1965	6
1966	5
1967	6

7. Expenditures Associated With Scientific Activities

7.1 The following table (7.2) itemizes the expenditures by the R & D Division broken down into the requested categories. The allocation of dollars to the various categories represents the best estimate available at this time as the Company accounting procedures do not provide break-downs of this nature.

7.2 R & D Expenditures Associated With Scientific Activities

	1962	1963	1964	1965	1966	1967	est 1968
(a) Functions							
5 - Industrial R & D	279,567	597,425	959,331	765,714	593,856	626,713	450,000
6 - University Support	67,450	171,684	62,600	54,725	53,845	47,500	25,000
- CURF donation	37,391	46,739					
	384,408	815,848	1,021,931	820,439	647,701	674,213	475,000
Scientific Discipline							
1 - Engineering & Technology	184,408	215,848	421,931	320,439	347,701	424,213	285,000
2 - (e) Chemistry	200,000	600,000	600,000	500,000	300,000	250,000	190,000
	384,408	815,848	1,021,931	820,439	647,701	674,213	475,000
Area of Application							
1 - Nuclear Energy	284,408	580,848	671,931	310,439	572,701	624,213	400,000
9 - Industry	100,000	235,000	350,000	510,000	75,000	50,000	75,000
	384,408	815,848	1,021,931	820,439	647,701	674,213	475,000
(b) Operating Costs	363,550	753,513	880,281	712,062	611,399	637,035	420,000
Capital Costs	20,858	62,335	141,650	108,377	36,302	37,178	55,000
	384,408	815,848	1,021,931	820,439	647,701	674,213	475,000
(c) Costs of University Eduction of Staff	460	550	6,000	11,600	5,700	7,500	8,200

Eldorado Brief to Senate Committee

8. Selection of Research Programmes and Projects

8.1 Intramural or "In House" Programmes

8.1.1 The choice of research programmes is made in accordance with the major objectives of the R & D Division as previously outlined in paragraph 2.1.

8.1.2 Individual projects relating to any of the Company's existing processes or products are very often of the "firefighting" variety designed to quickly answer a specific question or solve a specific problem. Longer range programmes in these areas may be suggested by the operating divisions, or may be obviously required because of a particularly troublesome or inefficient part of a process or an undesirable characteristic of a product.

8.1.3 The selection of programmes designed to expand the Company's sphere of operations is made in accordance with the following major criteria:

a. The process or product must utilize Company personnel's special abilities and know-how achieved in other fields.

b. Raw materials should be available in Canada, preferably as a Canadian ore or concentrate presently being exported in that form.

c. The end product of the resultant commercial plant must either not now be produced in Canada or be presently produced in insufficient quantities to supply the Canadian and expected off-shore markets.

8.2 Extramural or University Research

8.2.1 Research contracts with Canadian universities have been in force for the entire period under review (1962 to 1968).

8.2.2 The total level of financial support to universities in any particular year is usually decided within the R & D Division, and depends upon the availability of corporate funds to the Division.

8.2.3 The distribution of available funds between competing projects at different universities is decided within the R & D Division and is based upon the following factors:

a. The capability of the specific university departmental staff in the areas of Eldorado interest.

b. The applicability of the university's suggested programme to Eldorado's corporate objectives.

c. The level of financial support required to carry out a specific programme or to achieve a specific objective.

8.2.4 In some cases a competent university department will propose projects that do not meet our specifications outlined in (b) and (c) above. Under these circumstances the Company will specify the programme to be carried out and the level of financial support available.

8.2.5 Eldorado financed projects carried out by universities are monitored by quarterly reports to the Company and personal visits by Company personnel to the universities at least once per year. Projects are terminated or changed at the discretion of the Company but usually with the consent and support of the university researchers.

9. Measures of R & D Output

9.1 The statistical measure of R & D output for the period under review is shown as follows:

	1962	1963	1964	1965	1966	1967
Patents applied for	-	1	1	2	4	-
Journal articles	2	1	3	3	3	3
Papers presented	-	1	1	3	2	5
Reports issued	20	22	20	20	11	7

The decrease in number of reports issued during 1966 and 1967 is the result of a policy of secrecy adopted toward dissemination of information on the major research projects of those years.

9.2 A brief description of the work done by the R & D Division for the last five years will be presented under the following five headings:

a. Related to uranium milling.

b. Related to uranium refining.

c. Nuclear materials other than uranium

d. Non-nuclear materials

e. Custom work.

9.2.1 R & D Projects Related to Uranium Milling

The most significant projects in this field involved the metallurgical assessment of the Company's orebodies at greater depth and extensive testwork to improve uranium recoveries from this ore.

Minor projects were carried out to improve efficiencies of specific parts of the current process and to evaluate substitute processing elements. The largest projects in this category were solvent extraction in pulp and ion exchange recovery testwork from laboratory to pilot plant stages.

9.2.2 R & D Projects Related to Uranium Refining

Extensive projects were carried out on many phases of the UO_3 processing flowsheet. The development of a continuous UO_2 process has been a continuing programme over the last few years. The treatment of enriched uranium products and recovery of U^{235} from enriched scrap materials has occupied the Division's interest frequently throughout this period.

9.2.3 R & D Projects on Nuclear Materials Other Than Uranium

The largest project in this category is the recovery of nuclear grade zirconium metal from ores and concentrates. This project began in 1964 with a nuclear grade oxide as starting material and a complete flowsheet was developed. In 1966 and 1967 zircon sand was substituted as starting material and a revised flowsheet developed from bench scale, through pilot plant and semi-commercial scale testwork. At the present time the full-scale commercial plant is under construction and operation is scheduled for late 1968.

9.2.4 R & D Projects on Non-Nuclear Materials

Extensive testwork was carried out in 1963, 1964 and 1965 on methods of recovering cobalt, nickel, copper and silver from a wide variety of residues, ores and concentrates.

A complete flowsheet was developed for extraction of cobalt, nickel and silver from refinery speiss and scrap cobalt metal and tested on a large scale in the Port Hope Refinery. Market and economic conditions at that particular time were not favourable for the construction of a commercial operation.

Processes were developed for other materials including molybdenum metal and purified oxide, tungsten oxide, barium titanate and other ceramics during this period. Some sales of the high purity ceramics and cermets were made but no major commercial production undertaken by the Company.

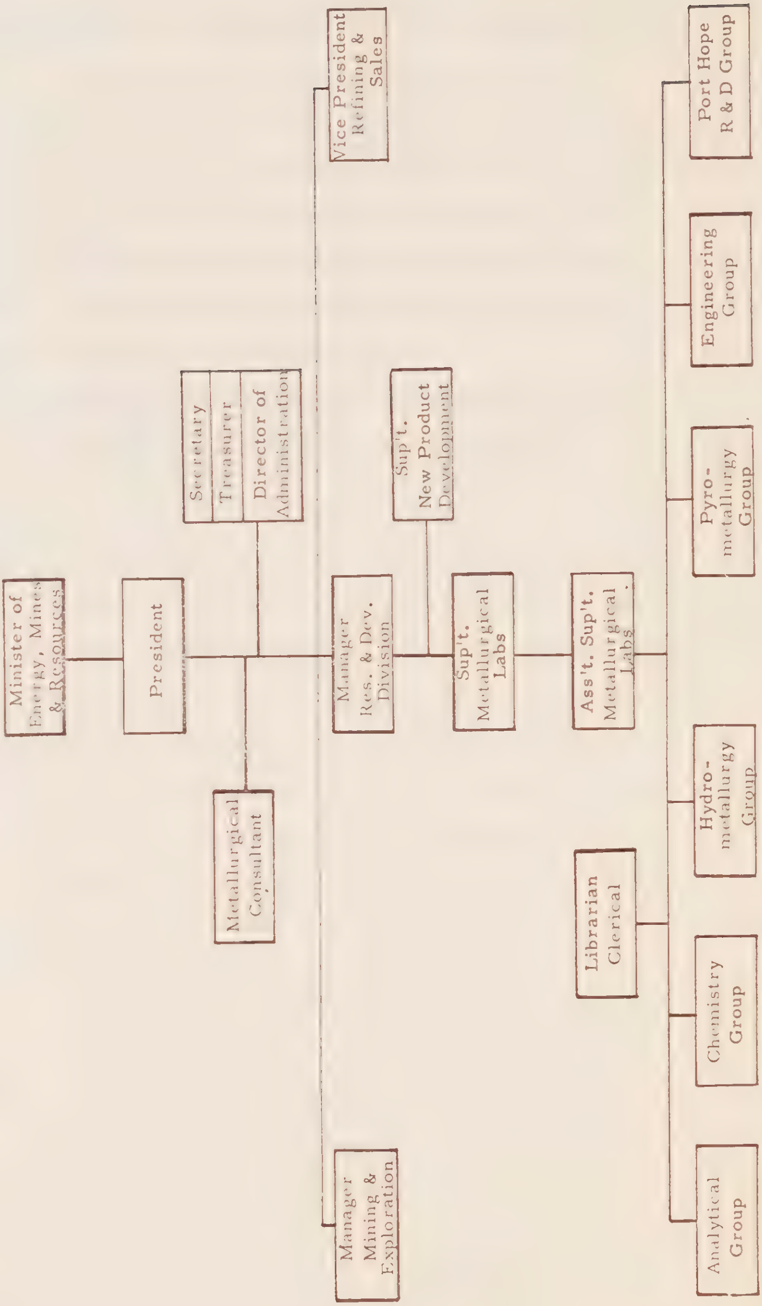
9.2.5 Custom Work

During the period under review the R & D Division carried out a number of projects for specific customers. These were primarily in the areas of metal or mineral recovery from ores and concentrates, purification of products by solvent extraction and some work in the refractory brick field.

In most custom projects, the Division's special capabilities and facilities developed for nuclear materials are often applied in non-nuclear areas with very successful results.

ELDORADO NUCLEAR LIMITED

ORGANIZATIONAL CHART - RESEARCH AND DEVELOPMENT DIVISION



First Session—Twenty-eighth Parliament

1968

THE SENATE OF CANADA

PROCEEDINGS

OF THE

SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*

The Honourable DONALD CAMERON, *Vice-Chairman*

No. 7

THURSDAY, OCTOBER 31st, 1968

WITNESSES:

Canadian Patents and Development Limited: Dr. B. G. Ballard, President; Air Marshall (ret.) C. L. Annis, General Manager; F. R. Charles, Secretary-Treasurer and J. R. Johnson, Chief of Development and Promotion.

APPENDIX:

7.—Brief submitted by Canadian Patents and Development Limited.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29339—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday, September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—

The question being put on the motion, it was—

Resolved in the affirmative."

29339—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—
Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

THURSDAY, October 31, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3:30 p.m.

Present: The Honourable Senators Donald Cameron (*Vice-Chairman*), Aird, Bourget, Grosart, Kinnear, Lamontagne, Leonard, Robichaud and Thompson—9.

Present but not of the Committee: The Honourable Senators Benidickson and McGrand—2.

In attendance:

Philip J. Pocock, Director of Research (Physical Science).

The following witnesses were heard:

CANADIAN PATENTS AND DEVELOPMENT LIMITED

Dr. B. G. Ballard, President.

Air Marshal (ret.) C. L. Annis, General Manager.

F. R. Charles, Secretary-Treasurer.

J. R. Johnson, Chief of Development and Promotion.

(*A curriculum vitae of each witness follows these Minutes.*)

The following is printed as an Appendix:

7.—Brief submitted by Canadian Patents and Development Limited.

At 5.30 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Ballard, Bristow Guy, Scientist, President, Canadian Patents and Development Limited. Dr. Ballard was born in 1902 at Fort Stewart, Ontario. DEGREES: B. Sc. Queen's University 1924; Hon. D. Sc. Queen's University 1956, Assumption University of Windsor 1961, Memorial University of Newfoundland 1964; Hon. D. Eng. Nova Scotia Technical College 1964; Hon. LL. D. University of Victoria 1965, University of Strathclyde 1967. CAREER: 1925-30 Westinghouse Electric and Mfg. Co., East Pittsburgh, U.S.A.; 1930 joined National Research Council of Canada's Division of Physics and Engineering; 1946 appointed Assistant Director, NRC Division of Physics and Engineering; 1948 appointed Director, Radio and Electrical Engineering Division; 1954 appointed Vice-President (Scientific), NRC; 4 February 1963—31 August 1967 President of National Research Council of Canada; 21 June 1967 elected to present appointment; HONOURS AND DISTINCTIONS: Officer of the Order of the British Empire 1946; Ross Medal, Engineering Institute of Canada 1949; Coronation Medal 1953; Fellow Institute of Electrical and Electronics Engineers; Hon. Member, Engineering Institute of Canada 1960; Fellow, Royal Society of Canada 1963; Hon. Member, Instrument Society of America 1964; Sir John Kennedy Medal, E. I. C., 1965; Centennial Medal 1967. OTHERS: Various appointments in Canadian Standards Association including President in 1963; various appointments in Engineering Institute of Canada including President 1961-62; various appointments in the American Institute of Electrical Engineers including Vice-President 1956-58; served on Edison Medal Committee and on the Awards Boards of the Institute of Electrical and Electronics Engineers 1963-67 and 1965-67; member of Queen's University Council since 1959; member of Board of Directors and an ex-President of Queen's University Alumni Association. MISCELLANEOUS: Canadian National Committee/International Electrotechnical Commission, President 1953-54; member of Carleton University Advisory Council on Engineering 1957-65; National Design Council 1961-64; Atomic Energy Control Board 1963-67; Canadian Government Specifications Board 1963-67; Defence Research Board 1963-67; Canadian Research Management Association 1963-; Science Council of Canada 1966-68.

Annis, Clare L., Air Marshal (ret.) RCAF, General Manager, Canadian Patents and Development Limited: Air Marshal Annis was born in 1912 at Highland Creek, Ontario and graduated from the University of Toronto with a Bachelor of Science Degree in Mechanical Engineering. He joined the RCAF in 1936 and trained as a pilot. CAREER: 1936-39 various military flying and technical courses; 1939-45 commander of various squadrons and stations in Canada and UK on anti-submarine warfare and on strategic bombing operations. During this period A/M Annis captained the first aircraft to attack a U-boat in North American waters; 1945 student at RAF Staff College; 1946-47 Chief Instructor RCAF Staff College; 1947-50 Director of RCAF Air Operations; 1950-52 Director of the Joint Staffs, Chiefs of Staff Committee; 1953—Student, Imperial Defence College, London, England; 1954-55 Chief Staff Officer, Air Defence Command; 1955-57 Chief of RCAF Telecommunications; 1958-62 Air Officer Commanding Air Material Command; 1962-64 Vice Chief of the Air Staff

and Air Member, Canadian Section of Can.-U.S. Permanent Joint Board on Defence; 1964-66 Chief of the Technical Services of the Canadian Defence Forces; May 1966 commenced retirement leave; 1 September 1966 joined Canadian Patents and Development Limited.

Charles, Frederick Roland, Barrister-at-Law, Secretary-Treasurer, Canadian Patents and Development Limited; born in 1911 at Toronto, Ontario and graduated from the University of Toronto with a Bachelor of Science Degree in Mechanical Engineering in 1933; continued his studies at Osgoode Hall and was called to the Bar in 1936; CAREER: 1938-46 legal officer with Sun Life Assurance Co. of Montreal with time out for military duty in Canada as an engineering officer with the RCAF during the Second World War; 1946-59 jointed National Research Council of Canada as a legal officer and performed both the general legal duties of the Council and also acted as the Chief Patent Officer of Canadian Patents and Development Limited after its founding; 1959, appointed General Council of NRC; appointed Secretary-Treasurer of CPDL; SOCIETIES: member of: Engineering Institute of Canada, Law Society of Upper Canada, Canadian Bar Association, Patent and Trademark Institute of Canada, Federal Lawyers' Club, Canadian Aeronautics and Space Institute, Chartered Institute of Secretaries.

Johnson, James Richard, Engineer, Chief of Promotion and Development, Canadian Patents and Development Limited; born in 1910 at Kamloops, B.C. and graduated from McGill University with the degree of Bachelor of Engineering in Mechanical Engineering in 1934; CAREER: 1934-37 engineering duties with Consolidated Paper Corp; 1937-40 Dominion Rubber Co; 1940-46 Officer in Royal Canadian Electrical and Mechanical Engineers, Canadian Army, served on active service overseas; post-war in Directorate of Vehicles and Small Arms, 1946-48 Maple Leaf Milling Co, 1948-53, jointed the NRC and served as a technical officer in NRC's Technical Information Service; 1953 joined CPDL and has served as Chief of Development and Promotion; SOCIETIES: Member of: Association of Professional Engineers of Ontario, Engineering Institute of Canada, Licensing Executives Society of America.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, October 31, 1968.

The Special Committee of the Senate on Science Policy resumed this day at 3.30 p.m.

Senator Donald Cameron (*Vice-Chairman*) in the Chair.

The Vice-Chairman: Senator Kinnear and gentlemen, we have with us this afternoon Canadian Patents and Development Limited.

The initial spokesman is a Canadian well-known to all of us, in the person of Dr. B. G. Ballard, who until recently was President of the National Research Council and now is President of Canadian Patents and Development Limited.

He will be assisted by another distinguished Canadian, Air Marshal C. L. Annis; by Mr. F. R. Charles, the Secretary-Treasurer; and by Mr. J. R. Johnson, Chief of Development and Promotion.

I presume, Dr. Ballard, that you will be making a brief statement along the lines of your brief.

Dr. Ballard: That is correct.

The Vice-Chairman: In view of the fact that you all have in front of you a biographical sketch of each of the members of this panel, I do not think that we need to go into it. With your permission, I will call on Dr. Ballard to proceed at once.

Dr. B. G. Ballard (President, Canadian Patents and Development Limited): Thank you, Mr. Chairman. Honourable senators, on behalf of Canadian Patents and Development Limited, we are most honoured to have been invited to appear before you and very glad to place ourselves at your service.

In our written brief we have attempted to provide a thoroughly illuminating and complete description of our Corporation and its activities, but I surmise that honourable senators may already have read the entire brief, so that I shall comment on it very briefly.

Expressed in condensed form, the object of Canadian Patents and Development Limited is to assist in making more available to the public, through industry, the patentable products of publicly-financed or publicly-performed research.

As honourable senators will recognize, our Corporation is neither a part of the research structure of our country nor is it a part of the industrial structure. It is a bridge which transfers science into the marketplace really.

I believe that at the first meeting this autumn of this Committee Mr. Maxwell Weir MacKenzie read a quotation from an American publication, and I would like the indulgence of this Committee to repeat one sentence of that quotation:

> We need to bear in mind that the path between an invention or idea and the marketplace is a hazardous venture, replete with obstacles and substantial risks.

Honourable senators, it is in this hazardous area that Canadian Patents and Development Limited is operating. We endeavour to put the ideas of the research laboratories into commercial practice. We do not assume all the risks, but we assumed a good portion in this process.

Of course, the patenting process is a risk in itself, and we bear all of that; but once a patent has been obtained, we must then proceed to put it into production as far as possible, and it is there that we endeavour to share risks with industry. We do this by entering into development contracts, very often with industry, but not always—sometimes with universities, sometimes with other laboratories—to develop a device to a point where it is likely to be profitable.

Our Corporation was brought into being by the National Research Council in 1947 to handle inventions which had accumulated largely from research in the Second World War. In 1954 the enactment of the Public Servants Inventions Act which, among other matters,

empowered Ministers to transfer to our Corporation the administration and control of inventions arising in their departments and agencies, had the effect of our Corporation becoming the Government's prime patenting and licensing agent. In the meantime we had negotiated with universities and some provincial bodies to handle patents which emerged from those organizations.

As of 31 March, 1968, our Corporation had received inventions for assessment from 27 different federal departments and agencies and had agreements with 18 Canadian universities and 5 provincial research organizations. The accumulated total of proposals for assessment—and sometimes these are referred to as disclosures—from all sources was 2,245, of which 172 were received during 1968. The rate of disclosure has increased by roughly 13 per cent per annum over the last three years.

Our Corporation examines these disclosures for patentability and economic potential, makes filings for patent in the patent offices or jointly with others certain inventions to which are deemed to qualify, develops alone or jointly with others certain invention to clarify their utlity or otherwise to make them more attractive to potential licensees, promotes and licenses inventions to industry, collects royalties and from these pays awards to inventors—or in the case of non-public servant inventors, to their parent organizations—and pays the costs of our Corporation's operations and administration. It should be mentioned here that the Public Servants Inventions Act authorizes our Corporation to retain and use the monies collected from royalties. I may say that part of that is returned to the inventors under the schedule set up by the Public Servants Inventions Act.

In our brief we enumerate the disclosures to us last year by individual sources, and we have classified the disclosures by types of inventions. In general, the largest federal contributors were the National Research Council, the Department of National Defence, the Department of Energy, Mines and Resources, and the Department of Agriculture, in that order. The input from the universities comprised about 17 per cent of the total. The largest segment of the inventions received comprised various types of instruments; the two next largest groups were concerned with nuclear technology and with the broad field of electricity and electronics.

From among the 2,245 disclosures our Corporation had received as at last March 31st, we filed application for patent on 660 and applications were pending on 350 more, for a total of 1,010 or 47 per cent of the disclosures. Our Corporation has been successful in obtaining issue of patent on about 93 per cent of its applications, which I think is quite commendable.

Using such data as the Canadian Patent Office was able to provide, it appears that the Corporation at present is handling about 6½ per cent of the total inventions for patenting from Canadian residents. We are not able to say what proportion of the total patentable arisings from these sources is handled by our Corporation.

We believe that the prompt disclosure first into the patent system by Canadian researchers is important both to the Canadian economy and to the researchers themselves. We have attached, as an appendix to our brief, the arguments which in our opinion make this course of action important.

The objective of our Corporations' Development and Promotion Branch is to license as many of the inventions in the Corporations' inventory as possible to industry under terms as advantageous to the overall interests of the Canadian public as can be judged.

I may say that we sometimes promote inventions which may not yield—and we even might not expect them to yield—handsome returns financially. One I can think of at the moment is a suturing device which we believe will have an impact on the Canadian public in a humanitarian way. The suturing device will become increasingly important, we believe, with the general increase in number of organ transplants. It enables surgeons to weld arteries in a fraction of the time that would be required by normal suturing practice.

However, the great majority of our inventions require at least some development before they can be put into commercial use or production; and many need extensive development.

Referring again to the quotation that Mr. MacKenzie read before the first autumn meeting, it is a broad generalization that for every dollar expended in the research phase of a project, ten more dollars, and sometimes much higher, are required to carry it through the development phase; and perhaps an additional hundred dollars to set up for commercial production and marketing.

We assist licensees pretty much all the way along the line. I would like to give you one

example. On our inventory we have a radar altimeter which is capable of measuring not only the altitude above ground but also above tree tops, which makes it possible to survey rather precisely forest resources, and which would appear to have very special application in South America. We have assisted in putting one of these units into service in South America to assess its performance. We have a licensee for that device, and I think that this may produce substantial results. This is just one example, and I could give you many. It is largely a public loss if we fail to do this, but again there are very considerable risks in all of these operations.

It is our practice to advertise the availability for licensing, in an "as is" state, of each invention as soon as we have filed an application for patent on it so that no time will be lost in transferring it to the marketplace—if possible. This, of course, results in numerous inventions finding licensees but, even so and despite our vigorous promotion, many of these publicly-owned inventions are unable to acquire licensees without some further publicly-financed input in the form of development.

We have had only small success in acquiring licensees among the larger industrial organizations, and most of our patents are put into production by smaller firms. I think there is perhaps a logical reason for this. The larger organizations have a well developed line of products, and they have not the same incentive to embark on new product lines as the smaller and growing companies.

This does present one drawback, because the larger firms almost invariably have an extensive and well developed marketing system, which the smaller firm does not have. Nevertheless, there seems to be no answer to this from the point of view of our own Corporation: this is a way of life with it.

A small but valuable proportion of the inventions which we receive are patentable as general processes but are dependent on these inventions being able to perform specific applications. For example, we have a group of related patents which, together, comprise a general process described as Microwave Heating. By this process, together with pertinent equipment, it is possible to apply microwave energy in such a way as selectively to heat one substance even while it is intimately associated with the other substances. There is, of course, a very large range of individual substances within a great many mixes, and it requires some considerable development to determine the correct constants for the equipment to handle any one application.

For example, in drying glues, one application is the striking strips on book matches. You can dry the glue, drive off the solvent extremely rapidly, by microwave heating without setting the striker material on fire—which obviously has some importance.

We had had other applications, some of which were successful, some of which were not. As I mentioned, we are interested in doing what we can for the Canadian public. One we tried but which was not successful, was a device to pasteurize beer in bottles, which technically can be done. I may say that you do not pasteurize beer for the same reason that you pasteurize milk. It is not to make it fit to drink or safe to drink; it is simply to preserve for a longer period of time its original flavour. However, this development has proved so far to be unacceptable on an economic basis.

The point is that for almost any one application it requires further development to assess the necessary constants for that particular application.

Our policy is, when necessary, to pay some or all of the costs of preliminary development. Preliminary development projects may be initiated as a result of an enquiry by an interested potential licensee, or, alternatively, our Corporation will initiate them, on selected inventions, in anticipation of finding interested licensees.

Honourable senators may already have noted that the nature of the work and the equipment comprising a preliminary development, is very similar in nature to the research done and the equipment used which produced the invention, and that in fact it can be regarded as almost a natural extension to that research. Indeed, in our search for contractors to conduct preliminary developments, it is our practice first to turn to the research laboratory which produced the invention and request it to accept a contract to do the preliminary development; hoping that the laboratory will be able to assign the original inventor, or someone working directly under the inventor, to the management of the project, and to use all or some of the equipment used in the preliminary research in the preliminary development. These arrangements, when possible, speed the development and hold down costs very significantly.

The alternatives are much less attractive. They comprise problems of finding, interest-

ing and training someone else, probably remote from the inventor, to conduct the development, find new space and buy new equipment. If the preliminary development contractor is a private company, he either has to charge commercial rates or else give our contract low priority, if he is to keep his business going; but the scale of costs is often not economically compatible with the odds for the preliminary development turning out successfully. To date we have had only limited success in persuading the research laboratories to accept contracts from our Corporation to do preliminary development work.

It might be well to mention here one reason why this is so. The scientists are in the business not so much to produce a marketable product as to pursue research and to find new scientific truths, and their reputation with their peers depends upon the published paper; so they are much more interested in presenting a new scientific truth to a scientific fraternity than they are in developing a useful "gadget"—which is about the way they look at it. Nevertheless, we do find some of them that are quite willing to do this, and quite willing to go ahead with further development of something that has emerged from their own laboratory.

The development, construction and testing of prototypes, pilot plants or the like, is commonly described as "engineering development". This phase is quite different and much more expensive than is the preliminary development phase. Our Corporation is willing to consider proposals from licensees for cost and risk sharing in the engineering development phases of inventions which they have licensed from our Corporation. In the financing of the engineering development, our Corporation is normally willing to advance up to 50 per cent of the estimated cost of a project. In the risk-sharing we may require a guaranteed return from the licensee, by an agreed date or dates, of some or all of our Corporation's financial input regardless of the extent of the licensee's earnings from sale or use of the licensed device, process or product.

The licensees retain management of engineering development projects in which our Corporation shares the costs, although we, of course, maintain rights of access to inspect progress and to terminate our support of projects in which we assess progress or prospects to have become unsatisfactory.

During the five-year period from fiscal 1962-63 to 1967-68, our Corporation paid out in cash a total of $489,500 toward the development of inventions. A total of seventeen inventions or "packages" of different inventions were so assisted. The largest single amount expended was $122,000 and some odd dollars, and the smallest $370.00, which is very small indeed. Preliminary developments and engineering developments each received approximately one-half of the total.

It should be mentioned that in our efforts to find a company willing to take a license on an invention which requires extensive development, we frequently find it necessary to offer the inducement of indirect financial assistance by way of a more favourable royalty rate or greater exclusivity of the licence. I may say here that in general we avoid making available exclusive licences, but sometimes it becomes virtually necessary to do this to attract a licensee.

In our promotion of inventions we employ five methods, namely:

1. Publication and distribution of a catalogue and advertising in periodicals;
2. Exhibiting at industrial exhibitions;
3. Encouragement of visits to the Corporation's offices;
4. Direct approaches to companies; and
5. Reciprocal agreements with organizations similar to our own in the U.K., Australia, India and South Africa whereby each handles the licensing and promotion of selected cases belonging to the other.

In its licensing our Corporation observes the policy set down by the Government in 1954. This policy will have been noted in our brief.

As I mentioned earlier, we handle inventions arising from eighteen of the Canadian universities as well as from government research laboratories. Disclosures from the latter sources comprise about 83 per cent and from universities about 17 per cent of our receipts. From among the disclosures from universities we have filed application for patent on about 22 per cent of them, and from among the disclosures from government organizations we have filed for patenting on about 50 per cent.

We have been able to obtain issue of patent on about 66 per cent of those inventions from universities on which we have filed applications, and we have obtained issues of patent on about 95 per cent of the inventions from government organizations on which we have filed applications.

In finding licensees to work the inventions on which our Corporation has filed application or obtained issue of patent, we are being successful in about 15 per cent of the university inventions and in about 35 per cent of the inventions coming from government organizations.

Whereas our experience indicates that the probabilities of a disclosure arising at a Canadian university has only about one chance in forty of going into commercial use, compared with chances of about one in six for disclosures coming from government organizations, an examination of comparable figures for U.S. universities suggests that Canadian universities enjoy a greater success in this field than do their U.S. counterparts. This may account for the fact that very recently an American university approached us to ask us if we would handle their patents for them.

In the U.S.A., Research Corporation, a non-profit organization established for the purpose in 1912, provides patent services of a nature almost totally comparable to those being provided by our Corporation in Canada, to about 180 colleges, universities and scientific institutions. In a Report of the Committee on Science and Astronautics of the U.S. House of Representatives, Eighty-Ninth Congress, 1966, it was stated that in the period 1946 to early 1966 Research Corporation received about 6,000 disclosures. From these about seven hundred applications for patent were filed. Of the sixty inventions which were licensed, just thirty yielded any income. In other words, less than 5 per cent of the inventions from U.S. universities which were covered by patents or patent applications were in actual commercial use; or only about one-half of one per cent of the inventions submitted were brought into commercial use. That is to say, whereas an invention from a Canadian university has about one chance in forty of going into commercial use, the chances of an invention coming from a U.S. university have been about one in two hundred.

We believe the higher success in licensing and commercial use of inventions arising in Canadian government research laboratories compared with universities is largely because the government projects are comprised of a higher proportion of applied research, the projects are generally of longer term, and the teams are more coherent for a longer period of time. Some university administrations do not feel sufficiently familiar with patenting to try to screen out intrinsically unpatentable arisings from their inventors before forwarding them to us. We experience no difficulty in that respect.

Figures could be provided which, if unqualified, would indicate that our Corporation, by being successful in licensing about one-third of the inventions on which it is filing applications for patents, is substantially outperforming the various agencies in the United States and the United Kingdom.

Perhaps at this point I might say something about the United Kingdom organization: it operates in a substantially different manner from the Canadian. It is supported by the government rather handsomely by our standards. At a talk given by one of their staff members within the last three weeks, he mentioned that in the chemical field the government—as he expressed it—"sloughed off" on them some twenty-five million pounds for development, which made me sit up and take notice. When I asked him if this meant that the government insisted on them accepting the money, he said: "Well, no, not exactly." I said: "Did you get this money without asking for it?" He said that, no, there had been some discussions. It just reveals the quite different order of magnitude of the operation of the two organizations.

An aspect of patenting and licensing which our figures illustrate is how long, on the average, any organization which has arisings of only a few possibly patentable disclosures a year might have to wait—and meantime the amount of unrecovered invention-handling costs it might have to carry on its books—until the one-in-a-hundred invention comes along which might put its patenting account into the black. Conversely, the figures illustrate the advantages of having a central organization such as our Corporation handling the arisings of inventions on behalf of a large group of sources.

Honourable senators will no doubt be conscious of how small a proportion of the disclosures of possibly patentable material, even those from applied research laboratories, is actually able to achieve commercial use; and you may be wondering what the public is getting in return for its expenditures in producing and marketing its patentable material. It is true that out of a total of 2,245 proposals for assessment which our Corporation has received over the years, more than one-half have been assessed as unsuitable for patenting; but, more importantly, all 2,245 were afforded the opportunity of expert evaluation.

When I say "expert evaluation", we not only rely on our own staff, who have become quite expert in this field, but we do consult outside people insofar as we may without serious disclosures, and we can discuss this with anyone in the government services.

Thus, to the extent that public-servant and university inventors are disclosing their thought-to-be-patentable material to their organizations and their organizations are forwarding it onwards to us, the public can be confident that patentable arisings are being identified and our Corporation is applying organized and conscientious assistance in trying to get the inventions into use. Our Board of Directors is comprised of members drawn from both industry and government, and our staff, which at present numbers 23, has been carefully tailored and specialized to match the nature and quantity of our workload.

In the matter of how much the public gains from this, it might be noted that the total royalties earned by the Corporation since its inception have been $3,393,000, and that, as a broad generalization, our royalty charges average from three to five per cent.

On this basis, it can be computed that the total business generated by the inventions which have been handled by our Corporation has been in the order of $85 million. In 1967-68 our total revenue from royalties was $311,058, indicating business generated was in the order of $7,750,000. It is not possible to estimate accurately how much the use of the products resulting from the manufacture or use of these inventions has contributed further to the economy.

Perhaps it would be of interest to note what the circumstances were when the Corporation came into being. I mentioned it was founded in 1947. At that time the National Research Council had built up a patents fund of slightly over $290,000, I think it was. When their patent work was transferred to the newly-formed company, that fund was transferred to the Company, and that has been our working fund really, although we have substantially increased it from our earnings so that now it is very close to a million dollars. It oscillates a bit; it has been over a million, and it is reduced at the moment; but this will give you some measure of the funds we use for operation.

We have paid out a total of $162,000 in awards to public servants in accordance with the Government regulations. We have borne the cost of invention evaluations, patenting, patent maintenance, assertions and litigations as necessary; have invested $806,000 in the development of inventions, have paid the costs of our general operations and administration; and, as I say, we still have on hand, $923,289.

There is no doubt that a very large proportion of our inventory of inventions does not have the intrinsic qualities necessary to compete in the market-place. On the other hand, we are hopeful that a higher proportion of our inventory may find its way into public use if we can find better methods of identifying the potential and of encouraging utilization of these publicly-owned inventions.

We intend to continue searching, experimenting and adopting any new procedures or techniques which appear to be more effective and economically beneficial to the public.

The Vice-Chairman: Thank you, Dr. Ballard. I have a note that coffee is ready, and this might be a good time to take a break. Then Senator Leonard will open up the questioning.

(Short recess)

Upon resuming:

The Vice-Chairman: It seems that scientist Dr. Ballard is as human as the rest of us. He has found he has omitted a point he wanted to make, and he craves the indulgence of the committee to register the point.

Dr. Ballard: Thank you, Mr. Chairman. I must say this point arose because of the questions asked me during the recess. It is quite apparent that I did not make clear what is the relationship between the National Research Council and Canadian Patents and Development Limited.

Canadian Patents and Development Limited is, of course, a Crown corporation which is subsidiary to the National Research Council; and I mentioned that the Research Council had a patent fund of some $290,000 which was transferred to the new Corporation.

In exchange for that they got a majority of the shares, so that they have a controlling interest in it and they are represented on the Board of Directors.

I neglected to say anything about the Board of Directors. This is made up of people from both Government departments and industry, but we are moving towards a greater industrial representation as the terms of the Board members expire.

Senator Bourget: How many directors representing industry do you have on the Board at the present time?

Dr. Ballard: At the moment there are officially only two members from industry, but there is one being appointed at the meeting of the Board coming up next month.

Senator Bourget: That is two out of ten, is it?

Dr. Ballard: Yes, but this is what we are endeavouring to increase, the industrial input.

Senator Leonard: May we have the names of the two, Dr. Ballard?

Dr. Ballard: One is Dr. Gendron, and the other is Mr. Wallace, President of Smith and Stone Limited.

Senator Bourget: Dr. Gendron represents—

Senator Leonard: Universities really, does he?

Dr. Ballard: No, we have no representation from universities, although this is something we have endeavoured to get, and we think we should have it.

Air Marshal (ret.) C. L. Annis (General Manager, Canadian Patents and Development Limited): May I say, when Dr. Gendron was appointed he was President of Dow Breweries; later he became President of the Pulp and Paper Research Institute, the appointment he presently holds.

Senator Bourget: When he was appointed was he Dean of Engineering here at the University of Ottawa?

Dr. Ballard: No, not at that time.

Senator Thompson: Is there any particular reason why you take one industry, a representative on the Board from one industry? Do you purposely go after a certain industry or not?

Dr. Ballard: We like to mix the industries so that we get a broader point of view. While I cannot reveal any names now, the new member we expect to get on the Board will represent still a third industry.

Dr. Gendron has had experience in more than one industry now, and he is really in the pulp and paper industry at the moment. Of course, Brigadier Wallace is engaged in the electrical industry. It is our intention to gradually increase industrial representation.

The Vice-Chairman: Now, Senator Leonard, are you ready to go ahead?

Senator Leonard: Yes, Mr. Chairman. My first question, Dr. Ballard, is not so much directly related to the operations of your own Company as to our patent law generally; and I am putting it to you as one who is experienced, with your colleagues, in the operation of our Patent Act and regulations; also because you are a public servant and therefore have the public interest at heart as we have too.

We are interested in how our patent legislation affects the development of new ideas and new inventions for better production and better productivity in Canada.

My question to you is: from your own experience have you any comment to make to us, or any suggestions, as to the operation of our patent legislation, whether applying to you or applying to individuals generally? Are there unusual obstacles that are placed in the way of development of new ideas; are there any improvements that might be made? Have you any comment as to the way in which our patent legislation affects our science policy in developing new ideas and inventions?

Dr. Ballard: I would like to ask Mr. Charles and Mr. Annis to comment on this. Mr. Charles in particular has been deeply involved in this sort of question.

Senator Leonard: Yes, I know that.

Mr. F. R. Charles (Secretary-Treasurer, Canadian Patents and Development Limited): Honourable senators, the Canadian Patent Act has been, in my humble opinion, half way between the English Patent Act and the American Patent Act in its effect on the individual inventor. By this I mean that in England the first person to disclose the idea, whether he is the true inventor of not, can get a patent. This is called "importation from abroad" and thus you can obtain a patent; because their philosophy in England was: "We are an exporting country. The first person to bring it in here we will give a patent and let him get busy and export". This was the start of the Statute of Monopolies.

The United States was all for building up their own industry, and a private inventor cannot use anything he has done outside the United States to try and prove a date of invention for his patent.

Canada, staying half way between, has said: "We will find who the first and true inventor is". The law here has been based on this very thing, that you can get into a conflict in the Canadian Patent Office, and an

American can win it if he can prove that he had developed the idea earlier, even in the United States. He does not have to do it in Canada.

This particular feature has been questioned a little lately by some people. I have heard this used as one reason why American companies will not do too much research in Canada, because the U.S. Patent Act says the only work that they can use to get a patent in the U.S. is work done in the U.S. The Canadian Act does allow this U.S. work to defeat our Canadian inventor possibly.

This is one area in which I think some study could be made, as to whether, as Canadians, we are being a little too generous. I have had something to do with the scientific research Income Tax rebate, and this is one of the things I had brought to my attention: that American companies will not set up to do research work in Canada because of their own Patent Act. They want to do it all in the States.

Senator Leonard: Thank you very much. Then, in effect, we were probably closer to the U.K. idea, at a time when perhaps we were not as much concerned as we are now with respect to our own development of new ideas and new inventions and the industry that might come from that. We are getting perhaps closer to the American thinking then we were perhaps some years ago.

Mr. Charles: Yes, I think this is so.

Senator Leonard: Have you any other suggestion along that line?

Mr. Charles: Have you something, Mr. Annis?

Air Marshal Annis: I am going to comment by reading a little bit from the Report of the U.S. President's Commission on the Patent System in 1966, and our views on that, if I may. It goes as follows:

> Agreeing that the patent system has in the past performed well its Constitutional mandate 'to promote the progress of . . . useful arts,' the Commission asked itself: What is the basic worth of a patent system in the context of present day conditions? The members of the Commission unanimously agreed that a patent system today is capable of continuing to provide an incentive to research development and innovation. They have discovered no practical substitute for the unique service it renders.
>
> First, a patent system provides an incentive to invent by offering the possibility of reward to the inventor and to those who support him. This prospect encourages the expenditure of time and private risk capital in research and development efforts.
>
> Second, and complementary to the first, a patent system stimulates the investment of additional capital needed for the further development and marketing of the invention. In return, the patent owner is given the right, for a limited period, to exclude others from making, using or selling the invented product or process.
>
> Third, by affording protection, a patent system encourages early public disclosure of technological information some of which might otherwise be kept secret. Early disclosure reduces the likelihood of duplication of effort by others and provides a basis for further advances in the technology involved.
>
> Fourth, a patent system promotes the beneficial exchange of products, services and technological information across national boundaries by providing protection for industrial property of foreign nationals.

This is on the broad policy of patent or not.

In this connection, I think it is our experience that a patent is most valuable to the little man and to the little company. The larger company is less dependent because it can to some extent use its powers of advertising and creating a want.

So that we subscribe, I think, to the general principles expounded in the extract I read, and I feel that for that segment of Canadian industry comprising the medium and small companies, which is the largest customer for the inventions we have to offer, the patent system is particularly valuable.

Senator Leonard: Thank you very much. Now may I go on to something about the finances of your Company.

The Vice Chairman: Before you ask that, may I just interject, Senator Leonard?

Senator Leonard: Yes.

The Vice-Chairman: I am wondering if this interpretation of the law explains one of the complaints that we have in this country as to why more American subsidiaries are not doing their research work in Canada.

Air Marshal Annis: Yes.

Mr. Charles: I think so.

Senator Leonard: I think that could be deduced from what Mr. Charles said.

Air Marshal Annis: This is true, I believe.

Senator Leonard: It is something our Committee perhaps might take into consideration.

Dr. Ballard, I notice that the last couple of years you have dropped the financial statement of this Company out of your National Research Council printed report. I imagine you have some good reasons for it, but I was interested to find out how you were getting along since then and I found that the information was in the Auditor General's Report, and that your net profit has dropped. I am not particularly concerned about that, but I did want to have your up-to-date information.

What I am really interested in—you do not pay any Income Tax, do you?

Mr. Charles: No.

Senator Leonard: That is a statutory exemption that you have. Then you no longer have to hand over any profits to the Consolidated Revenue Fund, do you? Once upon a time I think you did.

Mr. Charles: No, never.

Senator Leonard: So that the fund you have, your capital and your $920,000 odd, is in the nature of a revolving fund.

Dr. Ballard: Yes.

Senator Leonard: So that you can use that, plus any accretions that may come to it, for your expenditures for development purposes, plus your revenue.

I say that because in your brief, right at the very beginning and again on page 9 paragraph 24, you emphasize:—

> ...it would seem to be much to the advantage of the public if a governmental policy were proclaimed which would enable and generally encourage governmental research laboratories to enter into contracts with C.P.D.L. to do preliminary developments on such patentable products of research as in C.P.D.L.'s opinion merit such development.

At the beginning of your brief you make a recommendation to the same effect. You also, I think on page 12, refer to this Treasury Board minute, and emphasize the difference in the meaning of the word "development".

What I am wondering is: Are you saying that in some way or other you are restricted, whether by money, by direction or by manpower, in doing the things you want to do, that you ought to do, in developing these patents that come to you?

Air Marshal Annis: Yes.

Dr. Ballard: I do not know that it is so much a restriction on our part as a restriction that people with whom we want to deal have imposed on them.

Senator Leonard: You have the power; you are not being restricted at the moment, whether by money or otherwise.

Dr. Ballard: We are not being inhibited.

Senator Leonard: But other departments of government are.

Air Marshal Annis: Yes.

Dr. Ballard: Well, we believe so.

Air Marshal Annis: To some degree.

Senator Leonard: Can you specify something more directly as to in what way they are inhibited?

Dr. Ballard: In the main they get money from the Government for a certain character of work which may not embrace the sort of thing we want.

I think Mr. Annis could enlarge on this very effectively.

Air Marshal Annis: I would like first of all to emphasize that preliminary development is the aspect of development with which we are concerned in this connection.

In this business of clarifying the utility ot an invention to a specific application, as mentioned in our brief, from our point of view the most satisfactory organization with which to deal and to request to carry on beyond the research phase to do this clarification for us, is that same laboratory which produced the invention.

It has been our experience—I have been with the Company for only two years but throughout my total experience—that the laboratories are generally willing in spirit, but they are limited by laboratory space, manpower, funds and their own priorities.

We have enjoyed co-operation. The National Research Council has gone out of its way,

in connection with their inventions, to assist us as best they can, and they have made good contributions; but we do find delays in their ability to take on a project quickly, or perhaps at all, for the reasons I have mentioned.

Senator Leonard: It is really not so much that Government policy is against what you would like to see; but that when a particular department would have to put in its estimates a sum of money either for equipment or to enter into a contract with you, they either do not put it in or it is turned down; is that it?

Air Marshal Annis: We would have the money to offer to them to pay the salaries of the people that they assign to a task on our behalf; but sometimes they do not have the laboratory space, or they cannot make those people available, or they do not have the authorized manpower ceiling to take on the extra people within the limits set by Treasury Board; or, in the case of defence research, it may be that they are limited in their terms of reference to things which developing have a military connotation, and they are unable to move outside even to do a limited amount of development of something which has a commercial flavour.

Senator Leonard: Without getting into the question of overall Government policy, if you could sell this idea to any particular department of Government, it would be carried into effect, would it not?

Air Marshal Annis: We think it might assist them in their willingness to take on preliminary development projects if they had the means to do them. It has not been for lack of co-operative spirit. We have enjoyed a co-operative attitude wherever we have turned.

Our particular trouble is with inventions which originated in one laboratory (particularly universities) where they do not have the resources, in many of them at any rate, to carry an invention on into the preliminary development phase. The term ends, the team breaks up, and whatnot.

In such cases we are compelled to look for a full-time laboratory and ask it to accept a preliminary development contract. But for them it is an additional workload which has been un-programmed, and one they are unable under existing arrangement and without some sort of recognition of priority, to undertake.

Senator Leonard: This again may be a matter of science policy.

Then one last question. This Trasury Board minute prescribes the methods by which you establish your royalties. Does that restrict you? I think it is on page 12 of your brief, where it says:—

> The Crown should normally attempt to recover the full overall costs of patent exploitation, but not development costs...

and so on. Would you be able to obtain a higher royalty in some cases if it were not for that?

Air Marshal Annis: If I may, Dr. Ballard, I would like to answer the first part, and leave the detail to Mr. Johnson who does the negotiating.

I feel that vis-à-vis the United States, for example, we enjoy one very pronounced advantage, in that our Government regulations do permit us, when necessary, to grant exclusive licences, if this is in the overall public interest, if it is the only way in which we can find a licensee to get an invention into public use.

In the matter of the royalties that we charge, it has been made very clear to us by our Board that we are not in the business of us (C.P.D.L.) earning royalties for the sake of accumulating profits. The main criterion is the amount of business generated by our efforts.

So we have a very considerable latitude, and so far as I am aware, subject to Mr. Johnson's qualification in detail, we are not in any way handicapped with the licensing regulations as they exist.

Mr. J. R. Johnson (Chief of Development and promotion, Canadian patents and development limited): No, we are not. I do not think we can say we are restricted by any of these things that are here.

The negotiation of a licence agreement is a business operation: you negotiate the terms, and the royalty rates are set by negotiation. They depend largely on what you have got to sell. The price comes out as to what the thing is worth to the man you are licensing. This fluctuates, and this does not have any real bearing.

Senator Leonard: One last question. What is the size of the staff of the Company?

Air Marshal Annis: There are twenty-three at the moment, of which almost exactly half are secretarial, and the other half—

Senator Leonard: Executive?

Air Marshal Annis: Yes. The patenting staff. I should mention that in our patenting branch the majority of our officers are qualified as patent examiners. We farm out to patent firms about fifty per cent of our patent prosecution and the like and we do the rest of it in house. The remaining majority of our staff is the promotion branch, of which Mr. Johnson is the Chief.

Senator Leonard: Thank you very much. Thank you, Dr. Ballard.

The Vice-Chairman: Senator MacKenzie.

Senator MacKenzie: Mr. Chairman, you may have dealt with this when I was in the Senate. If so, you can disregard it.

I am interested in having Dr. Ballard or one of his colleagues say something about the work or organization in the university. I had a little to do with this when I was with the University of British Columbia, and I think it is fair to say that we were very happy to know that if the members of the staff produced something or thought they had produced something, they were able to turn it over to you to deal with and provide the best returns in respect of having the proposal patented, if it was so suited, and providing royalties if any were earned.

Now, understandably, the number of profitable patents that have been produced by the universities has been pretty small, because they are not, by and large, designed for those purposes; but there have been some, I believe...

Dr. Ballard: Yes.

Senator MacKenzie: ... that have been found patentable and have produced profits.

Do some of the university personnel still take out patents on their own, independent of you?

Dr. Ballard: Yes, this is quite true, because our agreement with the university gives each university the right to turn their patents over to us or deal with them privately. We cannot control that. We never know what is going through other channels.

The attitude of the universities, I think, is mixed. I was talking to one university president quite recently. He thought we were taking too large a share of the proceeds. It is a fact that we take a major part of the proceeds...

Senator MacKenzie: This is understandable, of course.

Dr. Ballard: ...during the early stages, to recover our expenses. In the last block I think they get 85 per cent; everything over a certain amount they get 85 per cent of the income.

Now, there are other universities that think this is a grand idea. I just came back from the University of Calgary. They have not an agreement with us yet, but they said this would come before their Board at the next meeting. The people with whom I was talking felt our agreements show a very generous outlook.

So we run the whole gamut of attitudes on the part of the universities. The plain fact is we are not making much money out of university inventories.

Senator MacKenzie: This is understandable.

Dr. Ballard: Most of our returns come from the Government laboratories.

There is a mixed feeling on the part of universities, and, as I say, we have not any idea to what extent they turn profitable patents over to us and to what extent they turn the residue over to us. We certainly know that in at least one university, which I would like not to mention, they attempt to promote their own profitable patents, and the unprofitable...

Senator Leonard: And they turn the other ones over to you.

Air Marshal Annis: May I add a point there?

Dr. Ballard: Yes.

Air Marshal Annis: You are undoubtedly aware that a very significant proportion of university grants come from other than government sources; and in connection with a great many of these there are stipulations that any patentable arisings from the research shall become the property of the grantee. So undoubtedly it is only a portion of the university-inventor products that are eligible to come to us.

Senator MacKenzie: We did not like that, incidentally, too much in the university policy, because we more or less assumed that members of the staff were full-time members of the staff; and that if they incidentally discovered something while they were working as members of the staff, then they at least ought to share that with the institution. However, I do not think it has been profitable enough to create many serious problems.

Dr. Ballard: I think one problem has been that very often grants coming particularly from the United States demand that the patent rights really go back to the United States. This is something over which we have no control and, I suppose, the university has not unless it wants to refuse to accept that sort of grant.

Air Marshal Annis: I was going to add, we are unable to accept an invention by a university inventor unless the university itself is able to take title and transfer the title to us for handling. So the matter of what university inventions we handle is a matter of the internal policy of each university.

In the newer universities, one of the aspects which slows down the process of entering into agreements with us is the resolving of the internal university patent policy. These are non-standard right across the country. Each university seems to have a patent policy that is slightly different from every other.

Senator MacKenzie: Have you found any particular areas in which universities are likely to be more productive of patents than others—medicine or physics or biochemistry or the like; or is this a chancy thing at best?

Air Marshal Annis: I have the figures with me. I think they are pretty well compatible with the performance of other laboratories, but the majority of inventions that come are various types of instruments. What would you say as to other products, Mr. Johnson?

Mr. Johnson: It varies quite a bit with the university. For example, in U.B.C. we have had a lot in the mining department because they were quite interested in this.

The most profitable one which has ever come out of a university was in the pharmaceutical field; but this does not indicate anything very much, I do not think, because this is a very chancy business as to which one turns out to be the better.

Senator MacKenzie: Was Forward's work in flotation patented?

Mr. Johnson: Some of his work was patented and came through us, but the majority of it was not. The majority of it went straight to Sherritt-Gordon because he was working for them.

Senator MacKenzie: You mean this is extra-curricular beyond what he was doing for the University of British Columbia: he also had a commission from Sherritt-Gordon?

Mr. Johnson: I do not know what the arrangement was.

Senator MacKenzie: I am not sure I know either.

Dr. Ballard: I think undoubtedly Sherritt-Gordon was putting a lot of money into this.

Senator MacKenzie: Oh, yes.

Dr. Ballard: And I think it was understandable they would like to get the patent right on what emerged.

The Vice-Chairman: Dr. Ballard, you said there was no university representative on your Board, and you were trying to get some. What has been the reason that you have not had any on the Board?

Dr. Ballard: This is rather an embarrassing question, but part of the reason is they have not been asked.

The Vice-Chairman: That is a good reason.

Dr. Ballard: Of course, getting members on any board is not just a matter of the president or even the executive staff saying: "We want this man."

The Vice-Chairman: I know. I was wondering though if having a university representative on your Board might assist in getting a more uniform approach to the university's role in the patenting field.

Dr. Ballard: We would hope that that would emerge. Of course, as you may know, we demand that each university have a patent policy if we are to make an agreement with them. They have to have a patent policy.

We did have Dean Jamieson of McGill on the Board for some considerable time, but at the moment we have no representative from a university.

Mr. Johnson: I think you could say the negotiations with us though have been responsible for firming up the patent policy of quite a few of the universities. They have come to more or less uniform arrangements in several cases because of their negotiations with us.

Air Marshal Annis: As a matter of fact, in recent years we have selected the patent policies of four of the major universities and, with their permission, have distributed them for the information of new universities which were preparing for or were in the midst of studying and adopting a patent policy.

Senator Bourget: Mr. Chairman, it has been mentioned that the Corporation had a favourable balance on hand of $923,000. This favourable balance has been built up through the years from the time that you did receive from N.R.C. the amount of $296,000?

Dr. Ballard: That is correct.

Senator Bourget: This was built up by your own organisation without any financial help.

Dr. Ballard: That is correct.

Senator Bourget: On the other hand, a few minutes ago Mr. Annis was saying that there was some kind of lack of lab. facilities. I do not know exactly for what purpose it was, but is that lack of lab. facilities due to the fact that the Corporation has not enough funds to develop these facilities, to get better facilities?

Dr. Ballard: We have not at any time set up our own research and development facilities. This is all contracted out. Our trouble has been not lack of facilities—we have not ever attempted to set these up; our trouble is getting outside contractors, if you like, to do development work that we considered necessary.

Senator Bourget: You also mention in page 20 that:

> ...despite its best efforts, at least two-thirds of the inventions in its inventory remain unlicensed.

Have you got any, I will call it, salesmen to sell them to some industries which would be interested, or is there enough contact with industry so as to sell those?

Dr. Ballard: We think we have a fair degree of contact with industry. Perhpas Mr. Johnson would like to speak to this.

Mr. Johnson: I think we have good contact with industry, but a certain number of these inventions are just not saleable, this is all there is to it. Some of them are obsolete; they have been displaced by newer developments. In some areas that are moving very rapidly, by the time you get a patent issued it may be obsolete; there may be a newer one come out the next day that spoils it.

There are others which are not saleable to Canadian industry because there is no Canadian industry of that type, and these we have to try to sell abroad. This requires more effort, of course, and sometimes it is difficult to do.

Senator Bourget: Are you selling many abroad?

Mr. Johnson: Yes, quite a few. One particular example would be a group of high vacuum instruments, for instance. There is no industry in Canada producing this type of instrument, and we have been successful in licensing these in the United States, Germany and England, because they are very good instruments; but we have not licensed all of this package. There are some of them that people just do not find a market for.

In assessing an invention and deciding whether or not you are going to file a patent application, you have to make this decision in the very early stages, and sometimes you are wrong. Sometimes there is no market for it, whatever the invention was. You take a chance, hoping that a market will develop or hoping that by the time you get the invention patented, Canadian industry will have expanded to the point where they can use it, but sometimes they cannot.

Dr. Ballard: I think it would be fair to say that at least one Canadian industry that I can think of has developed mainly because of inventions that we held, that they are using. Would this not be true of Guildline Instruments?

Mr. Johnson: Guildline Instruments would be a good example, and there is another example of one which was established in this country. We have a branch of an American company which was established in Canada specifically because we had patents on what they considered to be an important invention, and we would not license it for manufacture outside of the country. They wanted it, and therefore they came and set up a branch plant.

Air Marshal Annis: More recently still we have a French company establishing here in Canada very largely because of some patents we hold. They are just in process now of establishing.

Senator Leonard: It seems to me, Dr. Ballard, I remember years ago we tried to get Canadian industry interested in one of your patents and could not, and ultimately sold it to Italy, as I recall it.

Dr. Ballard: That is correct.

Senator Leonard: Where it was very productive and so on. I think at the time maybe there was some complaint about Canadian

industry not being ready enough to look into these things.

Has there been a change in that situation; would the same thing happen again?

Dr. Ballard: I suspect that Mr. Johnson can give a better answer to this. I would think there is some improvement, but I think it could still happen again.

Mr. Johnson: In certain fields. In that particular case there were probably three manufacturers in the world that made that class of equipment. We approached the top two and they would not touch it. This was a breakthrough into new ground, and they would not play with it at all. They were quite happy with the type of equipment they made. The third in the line was a little more hungry and a little more open to new ideas, and he took it on.

We had approached Canadian industry. While it is true that you could have found somebody who could have made it, there was nobody that could have sold it and serviced it. You just cannot start on a new piece of equipment and start a whole business with a sales organization and this sort of thing, because this has to be sold internationally. There is not enough market in any one country. So there was no Canadian industry that felt they could take it on. This could happen again.

Senator Grosart: What was that project?

Mr. Johnson: That was an analytical plotter for photogrametric work.

Senator Bourget: This was given to us by Dr. Schneider, I think. Was it that example that was given to us when Dr. Scneider appeared before the Committee?

Mr. Johnson: It could be, yes.

Senator Bourget: He said they are now selling about $23 million a year.

Mr. Johnson: That was really not quite an accident but it was a fortunate occurrence for the people that took the licence, in that after they took the licence the American Government became interested in the thing and let some large development contracts to have equipment built. No one knew this at the time they took the licence.

The Vice-Chairman: Senator Grosart.

Senator Grosart: Dr. Ballard, I would like to come back to your recommendation and the comments that Senator Leonard made in his opening remarks.

You seem to suggest, when you use the words "enable" and "encourage" in respect of Government laboratories, that there is some degree of inability and perhaps lack of enthusiasm at the moment. If a Government policy were proclaimed, have you any specific ideas as to how you might reach your objective through some kind of Government action? Governments do not normally merely proclaim a policy and get any action out of it. Have you any specific suggestion as to how this single recommendation that you make might be made effective?

Dr. Ballard: I will let Mr. Annis field that one.

Air Marshal Annis: We wrote a letter about a year ago to all of the departments of Government which operate substantial research laboratories, and stated our problem of obtaining their agreement in entering into preliminary development contracts, and asked what would be their attitude, their policy.

The letters which came back in each case stated that they were sympathetic to our problem but (as I mentioned earlier) that for various reasons—their budgets, their manpower ceilings, their existing programs and their existing priorities often might not permit introducing an additional program, which was not research actually but was the first stage of development into their activities.

In the case of the Defence Research Board they were limited also by the commercial nature of our requests, because they are constrained to the defence field.

Although we had a sympathetic response from them as individuals, and have had sympathetic treatment in every instance in which we have approached them with a specific request, I think they are confronted with the realities of the Treasury Board, budgeting, and all these matters that Deputy Ministers are confronted with; and if they did perchance insert into their annual budget an amount of $50,000, or five extra people, or same means to keep a little bit of extra manpower available in case a development project were requested by us, they would have to justify that entry in their next year's budget and program.

I do not know whether it is that we are not persuasive enough or the subject is not large enough to put us over this sort of hump. We feel that perhaps expression of willingness on the part of the Treasury Board to not only

allow but to encourage research laboratories within the Government to take on those projects which we cease as being of sufficient significance to justify a bit of preliminary development, would perhaps achieve this end.

I should modify my statement by saying we are having some success; we are not having just failures by any means. We are having a more difficult time than we like—and I do not want to have that misconstrued. We understand the problems of the research laboratories, but we occasionally see good projects not being taken over the preliminary development hump which with a bit more push, could obtain development, and, certainly in the public interest, should.

Senator Grosart: I hope you will be able to make some specific suggestion, because some of us have been reading the Science Council's Report, and the whole emphasis there is that we must get over this hump.

Yet here you give us evidence that you are coming to people and saying: "Here is how you do the very thing that the Science Council says is the major priority at the moment in science policy"; that is, to get into the development stage.

As I understand it, in offering the money and the co-operation that you are offering, you emphasize the word "preliminary". It is exactly in this area that you find people needing encouragement and lacking the ability to get into it.

Air Marshal Annis: Yes.

Senator Grosart: What do we recommend to the Government; what do we say to the Government should be done about this? You have written letters to all the departments.

Air Marshal Annis: Yes.

Senator Grosart: You have written letters to the people who are un-encouraged already. Have you any kind of suggestion? I am not asking you to come up with an Act of Parliament or anything, but it seems to me that from your experience there must be some way, because you do say "A governmental policy to be proclaimed."

Air Marshal Annis: Yes.

Senator Grosart: I know you know your business well enough to suspect that you have something a little more positive than that. Maybe you do not care to go that far, but it would be helpful to us, I think, if you could indicate the kind of thing that might be done to help you in this very vital area; because it is an amazing thing, it is the first time we have had a situation where somebody complains: "We cannot get people to take our money."

Air Marshal Annis: We can. As we mentioned, Mr. Johnson could be successful in going to commercial organizations, and paying for the new equipment, the training of the people, and the work and their doing it at commercial profits; but we are dealing in an area where the possibilities of failure are pretty high, and if we pay an abnormally high price for preliminary research then the economic odds run the wrong way.

We think it is the sort of work that needs to be done, if it is going to be public money that is spent at as close to cost as possible, in order to make this type of development economically sensible.

As Dr. Ballard mentioned at the beginning, we are dealing with a very tricky area when we are making a decision that something should be developed and then starting down the road. There are many cases where, having started down the road, the project gets out of control. This is the sort of danger that always lies in the development activity.

Senator Grosart: Senator Leonard was thinking the same thought as I was: Have we a lot of little ING's around?

Air Marshal Annis: Precisely.

The Vice-Chairman: I wonder, Senator Grosart, if Dr. Ballard and his associates would be agreeable to thinking about this and write us a letter setting forth specific proposals. Would you be prepared to do that?

Senator Grosart: I would be unfair to press the question at the moment, I agree with that.

Air Marshal Annis: I suspect the solution may lie in some sort of collaboration with Treasury Board, to allow a little lump sum somewhere to be set up that could be made available to specific departments within the year for the sort of purpose we have been discussing.

Senator Grosart: That is the hard way.

Air Marshal Annis: It may be the hard way. May I cite a case? I am perhaps reluctant to mention it as a specific example because we have had so much co-operation from the National Research Council, but as an example.

There is a process which may not be a terribly valuable one but which we thought might deserve some further investigation. We have called it reverse osmosis. It is a means of separating out one substance from another —a liquid—by having a controlled pore size in the diaphragm, so that the pores would be small enough that they can keep some molecules from going through and allow others to go through. Initial research was done, I think, to try to separate out salt molecules and desalinate water.

We had put money aside in this particular case to ask for some preliminary development and specific work. We were interested, as a matter of fact, in the maple syrup and maple sugar area, in separating out and concentrating maple syrup by this technique.

We approached the particular division in the National Research Council, and in this case there was a matter of manpower ceiling, of total numbers allowed to the Council. To do this job required breaking through the manpower ceiling which had been set. It could have been done by the Council, but it would have been really very disruptive to an organization which has been very co-operative in taking on this preliminary development work for us. It illustrates too, the sort of problem they have. We felt, within our Company that, with their concurrence, we could have hired people that were suitable to them, supplied these people to them and paid their salaries; and they could do the preliminary work, and when the work was done the contract would be over. But the flexibility in adjusting manpower establishment or in money or adding extra facilities, is restricted in laboratories which are already fully loaded and fully programmed well ahead.

Senator Grosart: I appreciate you are not making a general complaint.

Air Marshal Annis: No.

Senator Grosart: However, you do say that you are running into specific road blocks.

Air Marshal Annis: Yes.

Senator Grosart: You are sufficiently concerned about them to make this your major recommendation. I leave that for the moment, but it seems to me that this is somewhere not too far from your "one dollar" area on page 6.

Air Marshal Annis: Yes, it is, exactly; it is the "dollar" area.

Senator Grosart: It is way up there. It is not in the hundred dollars-for-one area.

Air Marshal Annis: No.

Senator Grosart: So you are not suggesting huge expenses here.

Air Marshal Annis: No.

Senator Grosart: Just a little more money to get over this hump.

Another thing, Mr. Chairman, if I might suggest it to our witnesses: if they decide to send us along any further thoughts on this, it seems to me—and this is just a personal viewpoint—that it might be helpful if you also looked through our guide lines. There are a few questions there that are not answered in your brief. They may seem unimportant to you, but when we come back to compare the answers, I think if you look through again—I know that you cannot answer every question in here because every question is not applicable—I would suggest to you there are some that it would be useful to us if they were answered. I am not going to take the time now to run down them. I have marked them here, the ones you have not answered but I thought it would be helpful if they were.

Air Marshal Annis: May I say, if there is failure to answer, I would be the guilty officer. I went through the guide and it was, of course, directed to research organizations; I ticked off everything that I thought was applicable to us. If we have failed to answer, I do apologize. It was misinterpretation.

Senator Grosart: I am not suggesting it is deliberate, because you are quite right that the brief makes a distinction between those departments that are fully engaged in science and those that are away on the periphery. I quite understand you may have done this. Perhaps we can leave it to our own Secretariat to suggest to you.

Air Marshal Annis: If they could be identified, we would be very pleased to co-operate.

Senator Grosart: I am not suggesting for a moment that there was any deliberate attempt. I am only saying that, looking at it from a comparative point of view I notice a few things where I would like to see how that compares with another answer.

The Vice-Chairman: Gentlemen, there is a suggestion that we try to finish this up by five-thirty, because we have another engagement about five forty-five.

Senator Thompson, did you have a question? I though I saw you put your hand up a while ago.

Senator Thompson: It is really following on Senator Grosart's. I think it is perhaps implied in his.

I was interested in your remarks about scientists being more interested possibly in producing papers than being concerned about gadgetry with respect to patents. You had also pointed out that by patents we get revenue.

I wondered, because of the Treasury situation and as an argument to Treasury, though I realize this perhaps could be very difficult: from the point of view of the ground work that is done on research, I would feel that possibly there could be examples where there had been ground work done by Canadian research departments; then, either in the States or somewhere else, they may have picked up on this and developed patents themselves, which would show a loss of revenue to us. Can you point out such examples?

Air Marshal Annis: I cannot off the top of my head.

Mr. Johnson: The most glaring example of that, which is not related to us, of course, is penicillin, which was discovered in England but developed in the United States, and they reaped all the income from it. We have not such a glaring example as that.

Air Marshal Annis: What about "Janet"?

Mr. Johnson: The "Janet" system? We keep on getting reports that the Americans have invented this again, but . . .

Mr. Charles: It was licensed to an American company by us originally.

Senator Thompson: I would think, in showing our want of co-operation from the Treasury, if we could show where we had loss of revenue because there had not been more development, it would be a persuasive argument to the Treasury.

Senator MacKenzie: Speaking of penicillin reminds me: we did keep the rights to insulin, did we not?

Mr. Johnson: Yes.

Senator Leonard: Canada did, yes.

Air Marshal Annis: Yes, indeed.

The Vice-Chairman: I wonder, going back to this matter of the interpretation of the Patent Act as it applies to American subsidiaries, if Dr. Ballard and his associates have any more specific suggestions that they might make to us, to tie this down in more practical terms, would they feel like passing it on to us?

This may be getting into a dangerous, gray area, but we shall be expected to deal with this in some way or other, and you could be very helpful possibly.

Senator Grosart: May I ask when the Patent Act was last reviewed and revised?

Mr. Charles: Major review was 1935, sir.

Senator Leonard: What about the Ilsley Commission? Did that just deal with copyright?

Mr. Charles: No, it dealt with patents, but it has not been implemented. They have never brought an amendment in to the Act.

Senator Leonard: Nothing done to the Patent Act as a result of the Ilsley Commission?

Mr. Charles: Not to any extent.

Senator Grosart: This also applies to the Copyright Act, which has not been revised for about the same length of time.

Senator Leonard: Do you recall whether the Ilsley Commission recommended anything along the lines of your comments about our being in between the U.K. and U.S.A.?

Mr. Charles: The Commission recommended some of the provisions that are in the British Act, such as renewal fees, to make the Patent Office a more self-supporting organization. The Commission recommended basing the priority right on the filing date so as to do away with conflict proceedings.

Air Marshal Annis: Yes, first to file.

Mr. Charles: Yes, first to file; that is right.

Air Marshal Annis: It recommended a common test of the same kind as in most of the rest of the world. I think the U.S., Canada and the Phillipines are the three which insist on "first to invent" as the basis for awarding to the inventor. In all the rest it is a case of "first to file". This is a means of avoiding these interference actions.

The Vice-Chairman: Are there any other urgent questions?

Senator MacKenzie: It is five-thirty, sir.

The Vice-Chairman: I would like, Dr. Ballard, on behalf of the Committee, to extend our very deep appreciation to you, to Mr. Annis, to Mr. Johnson and Mr. Charles for the very useful information you have provided us with; and also to say we hope that you will follow up the couple of suggestions that have been made for supplementary information. Thank you very much.

Dr. Ballard: Mr. Chairman, we have been very grateful for the patience with which you have listened to our statements, and we shall certainly endeavour to get an answer to the questions that have been raised.

The committee adjourned.

APPENDIX 7

BRIEF
to the
SPECIAL COMMITTEE OF
THE SENATE OF CANADA
on
SCIENCE POLICY
from
CANADIAN PATENTS AND
DEVELOPMENT LIMITED
275 Slater Street, Ottawa 4, Ontario

CONCLUSIONS

A main conclusion—see para. 17 of the Brief:

"17. It is a broad generalization that for every dollar expended in the research phase of a project ten more dollars (sometimes much higher) will be required to carry it through the development phase; and perhaps an additional hundred dollars will be needed to set up for commercial production and to market it. Obviously the public money spent on the *research phase,* i.e. the patent-attaining phase, of many potentially valuable inventions—and the benefits to the public that would accrue to placing them into use—*is largely just a public loss unless these additional funds, facilities and manpower necessary for development are found.*

RECOMMENDATIONS

A main recommendation—see para. 24 of the Brief:

"24. From a CPDL viewpoint it would seem to be much to the advantage of the public if a governmental policy were proclaimed which would enable and generally encourage governmental research laboratories to enter into contracts with CPDL to do *preliminary* developments on such patentable products of research as in CPDL's opinion merit such development.

1. Canadian Patents and Development Limited (CPDL) is a Schedule C Agency Corporation of the Government of Canada designated by P.C. 4115, 24-9-52. The "Designated Minister" through whom CPDL reports currently to Parliament is the Chairman of the Privy Council Committee on Scientific and Industrial Research (P.C. 1963-773, 23-5-63).

2. Expressed in tabloid form the Object of CPDL is to assist in making more available to the public, through industry, the patentable products of publicly-financed and publicly or university-performed research.

3. The tasks performed by CPDL comprise:

(a) Receipt of "inventions" from the sources mentioned hereunder;

(b) Assessment of these inventions for patentability and economic potential;

(c) Making filings for patent in the patent offices of various countries on those inventions assessed as qualifying;

(d) Developing alone or jointly with others certain inventions to clarify their utilities in specific applications or otherwise to make them more attractive to potential licensees;

(e) Promoting and licensing inventions to industry;

(f) Collection of royalties and from these paying awards to inventors (or, in the cases of non-public servant inventors, to their parent organizations) and defraying the costs of CPDL's operations.

4. CPDL was brought into being by the National Research Council of Canada (NRC) in 1947 to perform, on behalf of the Council, such of the power conferred upon the Council, by paragraphs (h) and (i) of Section 13 of the National Research Council Act as the Council might from time to time direct, and all the issued shares of the capital stock of CPDL are owned or held in trust by the Council for Her Majesty in right of Canada, except shares necessary to qualify other per-

sons as directors. The Board of Directors of CPDL at present is set at ten members; and the members are drawn from across Canadian industry and pertinent government departments.

5. The accumulation of inventions resulting from NRC research during the Second World War was largely the cause of CPDL coming into being. Once formed, however, requests to handle their inventions flowed from an increasing number of government departments and agencies; and the enactment of the Public Servants Inventions Act in 1954 by the federal government which, inter-alia, specified that Ministers were empowered to transfer the administration and control of inventions to CPDL opened the way to CPDL becoming the Canadian government's prime patenting and licensing agency. Meantime CPDL had made provision for entering into Agreements with universities and provincial research organizations to handle their inventions.

6. As at 31 March 1968 CPDL had received inventions for assessment from 27 different federal departments and agencies (including all those which operate scientific research laboratories) and had Agreements with 18 Canadian universities and five provincial research organizations to handle their inventions. The accumulated total of proposals for assessment from all sources was 2,245 of which 172 were received during 1967-68. This was 14 more than the previous year, which, in turn, was 21 more than in 1966-67. It is difficult to forecast whether this annual increase of approximately 13% will persist.

7. Of the 172 proposals for assessment received in 1967-68 41 originated with the National Research Council, 37 from the Department of National Defence, 30 with Atomic Energy of Canada Limited, 13 from the Department of Energy, Mines and Resources, 7 from the Department of Agriculture, 9 from among four other government departments and agencies, 29 from universities and 6 from provincial research organizations. Among the universities forwarding proposals for patent the most received from any university was 6. Another university forwarded 5 and two others 4 each. A further eight universities contributed 10 proposals. No inventions were offered for assessment by seven universities.

8. Among the 172 proposals for assessment received in 1967-68:

—46 were various types of instruments (33 to do some kind of measuring or testing);

—23 were concerned with nuclear technology;

—21 were in the general field of electricity;

—14 were in the broad field of human necessities, e.g. agricultural devices, foodstuffs, etc.;

—the remainder were distributed through such fields as chemistry, metallurgy, performing operations, e.g. separating, mixing, metalworking, transportation, etc., and mechanics.

The distribution of kinds of inventions, e.g. the high proportion of instrument, nuclear and electrical offerings, was consistent with past years.

9. Of the accumulated total of 2,245 proposals for assessment which have been received over the years CPDL has obtained patents on 660 different inventions and applications were pending on 350 more. CPDL has been able to obtain patents on about 93% of the inventions on which it has filed application for patent. The aforegoing figures thus denote that CPDL has filed applications for patent on about 47% of the proposals for assessment which it has received.

10. Using such data as the Canadian Patent Office was able to furnish from its records it appears that CPDL at present is handling about 6½% of the total applications for patent which are made to the Canadian Patent Office by applicants residing in Canada.

11. It should be mentioned that approximately 90% of the inventions received from AECL are concerned with nuclear reactor technology and the promotion and licensing of these is handled by AECL.

12. CPDL has no reliable date to indicate what percentage of the thought-to-be-patentable material arising in federal government departments and agencies, Canadian universities and provincial research organizations is being forwarded to CPDL. Insofar as arisings in the federal departments and agencies are concerned it seems that almost all the inventions being disclosed by the inventors to the heads of their respective departments and agencies are being transferred to CPDL for assessment, patenting, development, promotion and licensing, etc. In their Agreements with CPDL the universities and provincial research organizations reserve the right to forward only such inventions as they elect. Only a portion of the university research in Canada is financed from federal grants and CPDL believes that a high proportion of the inventions arising from these is forwarded to

CPDL. At least some of research grants from other sources are on condition that the donors of the grants have title to any patentable arisings that may result therefrom. Thus CPDL is unable to state what proportion of the total patentable arisings of publicly-financed and publicly or university-performed research it is handling.

13. Although there are no reliable data available on what amounts of patentable material are *not* being disclosed into the patent system by researchers in the Canadian public service, universities, etc., it does seem important to the Canadian economy as well as being beneficial to the inventors themselves that patent protection should be sought for all worthwhile material arising in Canada. The text of a letter CPDL sent to all its sources of proposals for patenting which explains the importance and advantages of researchers disclosing all their possibly-patentable material into the patent system is attached hereto as Annex 'A'.

14. The staff of CPDL under a President (who is also chairman of the Board of Directors) and a General Manager is organized into two main operating divisions, i.e. a Patent Branch and a Development and Promotion Branch, as well as into orthodox administrative, financial and specialist services. The Patent Branch handles the work which has already been described, i.e. the receipt and assessment from a patenting viewpoint of proposals for patenting, the filing and prosecution of applications for patent, and patent maintenance. CPDL's legal staff drafts development contracts and licensing and other agreements and is concerned with the assertions and litigations which from time to time become necessary because of infringements on CPDL's patents.

15. The objective of the Development and industry under terms as advantageous to the inventions in CPDL's inventory as possible to industry under terms as advantages to the overall interests of the Canadian public as can be judged and negotiated in each case.

16. As already mentioned the great majority of inventions coming to CPDL are the patentable products of research made by scientists using laboratory equipment and on a laboratory scale. Therefore these inventions, in the state in which they reach CPDL, usually require at least some development before they can put into commercial use or production; and many need extensive development.

17. It is a broad generalization that for every dollar expended in the research phase of a project ten more dollars (sometimes much higher) will be required to carry it through the development phase; and perhaps an additional hundred dollars will be needed to set up for commercial production and to market it. Obviously the public money spent on the *research phase*, i.e. the patent-attaining phase, of many potentially valuable inventions—and the benefits to the public that would accrue to placing them into use—*is largely just a public loss unless these additional funds, facilities and manpower necessary for development are found.*

18. It is CPDL practice to advertise the availability for licensing, in an "as is" stage, of each invention as soon as CPDL has filed an application for patent on it. In as much as a period of about three to five years elapses between filing for patent and issue of patent this prompt advertising gives industry improved opportunity to apply for licenses to use those inventions which they assess as worth their developing and marketing. This results in numerous inventions finding licensees but, even so and despite vigorous CPDL advertising, exhibiting and direct approaches to individual industries, many of these publicly-owned inventions are unable to acquire licensees without some further publicly financed input in the form of development.

19. It should be mentioned at this point that CPDL has had only small success in acquiring licensees among the larger sized companies, i.e. companies large enough to operate or finance their own research. Thus the segment of industry which has benefited most from the patentable products of publicity performed research is the medium and small companies. Generally these companies need to expand or diversify their range of products but they seem to experience greater difficulties in financing and conducting development (and the associated research that sometimes becomes necessary).

20. CPDL is very conscious of the benefits that can accrue to the Canadian economy through the growth of smaller companies into flourishing enterprises.

21. A small but valuable proportion of the inventions reaching CPDL are patentable as *general* processes but success in finding licensees is dependent on these inventions being able to perform *specific* applications. As an example, CPDL possesses a group of related patents which, together, comprise a general process described as Microwave Heating. By this process, together with pertinent equipment, it is possible to apply microwave ener-

gy in such a way as selectively to heat *one* substance even while that substance is intimately associated with one or more other substances. In the applied research which produced the patentable inventions enough examples of selective heating were demonstrated to show justification for issue of patent. However there is a very large range of individual substances within a great many mixes of substances among which a variety of potential licensees may wish to heat selectively, for example heating and very rapidly driving off the solvent in the glue along the edge of a pad of paper or heating and very rapidly driving off the solvent in the striking strips on book matches without setting the strips on fire, etc. In order to interest a potential manufacturer in licensing the microwave heating patents for a specific application it is first necessary to show him that the process *is*, at least technically, able selectively to heat the substance in which *he* is interested. To do this requires a development project. (This *type* of development is often described as "*preliminary* development.

22. CPDL policy is, when necessary, to pay some or all the costs of "preliminary development". Preliminary development projects may be initiated as a result of an enquiry by an interested potential licensee or, alternatively, CPDL will initiate them, on selected inventions, in anticipation of finding interested licensees.

23. The reader may already have noted that the nature of the work and the equipment comprising a *preliminary* development is very similar in nature to the research done and the equipment used which produced the invention, and that in fact it can be regarded as almost a natural extension to that research. Indeed, in its search for contractors to conduct preliminary developments it is CPDL practice to turn first to the research laboratory which produced the invention and request it to accept a contract to do the preliminary development hoping that the laboratory will be able to assign the original inventor (or someone working directly under the inventor) to the management of the project and to use some or all of the equipment used in the research in the preliminary development. These arrangements, when possible, speed the development and hold down costs very significantly. The alternatives are much less attractive. They comprise problems of finding, interesting and training someone else probably remote from the inventor to conduct the development, finding new space and buying new equipment. If the preliminary development contractor is a private company he either has to charge CPDL commercial rates (or else give the CPDL contract low priority) if he is to keep his business going but this scale of costs is often not economically compatible with the odds for the preliminary development turning out successfully. *To date CPDL has had only limited success in persuading the research laboratories to accept contracts from CPDL to do preliminary developments,* particularly on inventions originating outside their own laboratories.

24. *From a CPDL viewpoint it would seem to be much to the advantage of the public if a governmental policy were proclaimed which would enable and generally encourage governmental research laboratories to enter into contracts with CPDL to do* preliminary *developments on such patentable products of research as in CPDL's opinion merit such development.*

25. The development, construction and testing of prototypes, pilot plants or the like is commonly described as "*engineering* development". The basic object of engineering development is to learn whether to go onwards into developing a production model or process and to ascertain the specifications which the production model or process should possess. In this phase competitive economic performance clearly shares attention with technical performance. Successful completion of engineering development often calls for some associated research. The reader will recognize that engineering development generally is much more expensive and requires equipment and facilities additional and different to those used in the research or preliminary development phases.

26. CPDL is willing to consider proposals from licensees for cost (and risk) sharing in the engineering development phases of inventions which they have licensed from CPDL and is often able to assist in obtaining some or all of the associated research. In the financing of the engineering development CPDL is normally willing to advance up to 50% of the estimated cost of a project. In the risk sharing CPDL may require a guaranteed return from the licensee by an agreed date or dates of some or all of CPDL's financial input regardless of the extent of the licensee's earnings from sale or use of the licensed device, process or product.

27. The licensees retain management of engineering development projects in which

CPDL shares the costs although CPDL, of course, maintains rights of access to inspect progress and to terminate CPDL support of projects in which CPDL assesses progress or prospects to have become unsatisfactory.

28. During the five-year period from fiscal 1962-63 to 1967-68 CPDL paid out in cash a total of $489,500 toward the development of inventions. A total of 17 inventions or "packages" of different inventions were so assisted. The largest single amount expended was $122,852.58 and the smallest was $370.00. Preliminary developments and engineering developments each received approximately one-half of the total.

29. It should be mentioned that in its efforts to find a Company willing to take a license on an invention which requires extensive development CPDL frequently finds it necessary to offer the inducement of indirect financial assistance by way of a more favourable royalty rate, or in the exclusivity of the license, or in the extent of the geographical area in which the license may be exercised, or in some combination of these.

30. In its promotion of inventions CPDL employs five methods:

—the publication and distribution of a catalogue of the inventions in CPDL's inventory which are available for licensing. The catalogue—called the Patents Handbook—is published in loose leaf form to facilitate the incorporation into it, by holders of the Handbook, of descriptions of new inventions as they become available. These are distributed in the form of amendments. The Handbooks are distributed on request and the number in present circulation is approximately 3050 of which about 2150 are to Canadian addressees. In addition CPDL advertises its inventions in various periodicals and in invention listing services, some of which have large circulations in other countries.

—CPDL exhibits regularly at industrial exhibitions. The CPDL booth invariably attracts substancial attention and produces good contacts which are followed up. This is the most productive single form of promotion that CPDL experiences.

—encouragement of visits to CPDL's offices by Companies interested in a particular invention or line of inventions. It is in this form of contact that CPDL can usually give the most complete assistance to prospective licensees. It often includes the examination of models or products in the CPDL model room or visits to the laboratories where the invention was made, or the like.

—direct approaches, both written and personal visits to companies. In these CPDL is careful not to give unfair advantage to one company if the invention seems likely to evoke an interest from several companies.

—CPDL has reciprocal agreements with the National Research and Development Corporation in the United Kingdom and with similar organizations in Australia, India and South Africa whereby each handles the promotion and licensing of certain cases belonging to the other in return for a percentage of any royalty income received.

31. In its licensing CPDL observes the policy set down by the government in Treasury Board Minute 468904 dated 18 August 1954. This Minute states, inter-alia, that the following principles are to govern the disposition of Crown-held patent rights:

a. The public interest is best served when inventions become generally available through successful commercial production.

b. Within Canada:

(1) Non-exclusive licenses should be granted where practical; exclusive licenses only where there appears to be no other expedient way of exploiting a patent.

(2) The Crown should normally attempt to recover the full overall costs of patent exploitation, but not development costs. To this end royalties should be calculated on the basis that when added to the cost of production the selling price will not deter the development and distribution to the public of such inventions.

(3) Where exclusive licenses are granted, however, due consideration must be granted in the fixing of royalties to the advantage granted the licensee as well as the benefit to the public in distribution of such development.

c. For exploitation outside Canada:

(1) Ordinary commercial principles should normally apply and appropriate royalty charges be made.

(2) Under special circumstances, royalty-free licenses may be granted to gov-

ernments of countries other than Canada.

32. In connection with the term "development" as first used in para. b(2) above CPDL interprets it to mean the research and any preliminary development needed to produce and "sell' the invention; and as used in the second sentence to mean the engineering or operational development to put the invention into use.

33. The reader may well be wondering what percentage of the patentable, publicly-owned inventions which enter CPDL's inventory does CPDL succeed in licensing to industry and how does this compare with performance in other countries, particularly the USA. Both of these questions are very difficult to answer; the first largely because a licensee for a patent (or, in some instances, several licensees) may be found at any time from about when the patent is first applied for until about three years or so before the patent expires—a total span of about 15-18 years. Therefore the fully-completed records are always more than a decade or so behind the times. The problem of comparing with the USA is so complicated as not to be meaningful partly because Canada has primarily just the one agency, CPDL, for handling publicly-owned inventions whereas the USA has a great many; partly because the proportions and ranges of Canadian and US research differ very greatly; partly because Canadian regulations permit granting exclusive licenses, if necessary, on Canadian government-owned inventions whereas in the USA exclusive licenses on government-owned inventions are, with some exceptions, *not* permissible; and for a number of other reasons.

34. Based on experience accumulated over the past fifteen years or so and using it to extrapolate the licensing performance accomplished during the five-year period 1962-63 to 1967-68, it can be stated, fairly accurately we believe, that CPDL is presently being successful in finding licensees for approximately one-third of the inventions on which it is filing applications for patent. (In making this estimate due allowance has been made for the fact that a high proportion of the inventions received from Atomic Energy of Canada Limited (AECL) are concerned with nuclear reactor technology and these are handled by AECL.)

35. In addition to handling the arisings of thought-to-be-patentable material from the research and development activities in publicly-owned laboratories CPDL also has Agreements for handling the arisings in 18 Canadian universities. In the USA, Research Corporation, a non-profit organization established for the purpose in 1912, provides patent services, of a nature almost totally comparable to those being provided by CPDL in Canada, to about 180 colleges, universities and scientific institutions.

36. In a Report of the Committee on Science and Astronautics of the US House of Representatives, Eighty-Ninth Congress 1966, it was stated that in the period 1946 to early 1966 Research Corp. received about 6000 disclosures. From these about 700 applications for patent were filed. Of the 60 inventions which were licensed just 30 yielded any income. In other words less than 5 per cent of the inventions from US universities which were covered by patents or patent applications were in actual commercial use. Or only about one-half of 1 per cent of the "inventions" submitted were brought into commercial use.

37. In 1948 CPDL entered into its first agreement with a university to handle its disclosures of inventions and by 1968 had such agreements with 18 Canadian universities. As at 31 March 1968 CPDL had received a total of 192 disclosures and from these had filed 42 applications for patent—a filing vs. disclosure rate of somewhat more than one in five. CPDL has been successful in obtaining issue of patent on about two-thirds of the university cases on which it has filed applications for patent (compared with issue on over 95 per cent from filings made from among disclosures originating in government research organizations). University disclosures comprise about 17 per cent of CPDL's annual receipts from all sources and about 8 per cent of CPDL's annual filings for patent. Of the total of 6 university inventions which CPDL has been able to license 5 have yielded some income. Thus about one-eighth of the university inventions which CPDL has covered by patents or patent applications are in use.

38. Whereas a disclosure of an invention to CPDL by a Canadian university has had considerably better success in gaining commercial use than has a disclosure from a US university to Research Corp. the fact still remains that the chances even of a Canadian university disclosure going into commercial use have been low compared with disclosures from Canadian government organizations, i.e. about one chance in 40 compared with about one chance in six.

39. CPDL believes the higher success in licensing and commercial use of inventions arising in Canadian government research laboratories compared with universities is largely because the government projects are comprised of a higher proportion of applied research, the projects are generally of longer term and the compositions of the individual research teams fluctuate less. Also some university administrations do not feel sufficiently familiar with the patenting process to try to screen out intrinsically unpatentable arisings from their inventors before forwarding them to CPDL. (This is *not* troublesome to CPDL.)

40. In an address some years ago the president of Research Corp. summarized the economics of licensing inventions as follows: "Experience has shown that *on the average* only about one in a hundred patents really yields a considerable excess of royalty income over patent and development expenses; only about nine patents out of the hundred show some net return and only twenty out of the hundred barely break even; the remaining seventy patents are a net loss to the patent owner. In other words, for a pool of patents to break even, the ten financially successful ones must more than carry the ninety which lose or just break even." The speaker was referring to the licensing of inventions arising from US universities. Insofar as licensing inventions from Canadian universities is concerned, CPDL's experience coincides closely with that of Research Corp. However, although CPDL has not investigated the comparable figures for royalty revenue from inventions arising from laboratories conducting higher proportions of applied research than has been the case in universities, CPDL experience indicates that more than nine in a hundred of the patents arising out of applied research—perhaps as many as fifteen among the hundred—may average some net return.

41. An aspect of patenting and licensing which the above figures illustrate is the difficulties which face an institution which has just small arisings of possibly-patentable material to handle each year. For example the *average* arisings of *patentable* inventions forwarded to CPDL throughout CPDL's twenty years of handling university inventions has been about 0.14 invention per university per year. It is clear that if each university handled the patent assessment, prosecution, maintenance, promotion, licensing, litigation and administration of just its own arisings it would have to wait *on the average* more than two hundred years before the one-in-one hundred highly profitable invention arose which could be expected to abate the expenses incurred meantime in handling the "losers" and to put the university patenting account into the black. On the other hand the fact that CPDL operates a "pool" for inventions has made it possible, insofar as the Canadian universities are concerned, for CPDL (as at 31 March 1968):

—to carry the costs ($48,846.48) of handling all disclosures including the very large proportion which have generated nothing but costs. (Such of these costs as are not yet abated will be recovered only to the extent that arisings of successful inventions at individual universities permit abatements of the net debits in the individual accounts that CPDL carries for each university. The debit entries comprise costs incurred by CPDL in handling the individual proposals for patenting.)

—to pay out a total of $162,078.60 to the two universities which have had royalty-earning inventions.

—to show a net surplus balance of $19,341 after 20 years of operating its Agreements with universities.

42. In assessing the figures about university inventions set out in the immediately preceding paragraphs it is an important point to note that because the "pooling" in CPDL of the handling of university inventions dramatically reduces the risks of financial losses to universities and university inventors it no doubt results in many more inventions being put forward for evaluation than would otherwise occur. Whereas it is true that out of 192 university disclosures which have been offered to CPDL 150 have failed to obtain filings for patents, more importantly all 192 *were* afforded the opportunity of expert evaluation and, as a result, 42 applications for patents were filed and *thus far* licensees have been found for six of them. Five of these six have earned royalty revenue. Although four of the five inventions have enjoyed only small earnings the fifth has been one of the one-in-a-hundred patentable inventions which are real "winners". As at 31 March 1968 the total royalty earnings of these five inventions was $231,265.91. This amount of royalties suggests that the *public* has benefited, in terms of the business generated by these inventions, to an amount in the order of $3,750,000. The invention which has been by far the greatest earner is a drug which trials showed to be effective in the treatment of Hodgkin's disease, leukemia and some cancers. It is not possible

to place a value on the benefits received by the users of the products of this invention.

43. Although a few government departments and agencies have arisings of up to about forty proposals for patenting per year these are actually quite small numbers and generally the same advantages apply to "pooling" the handling of their inventions with CPDL as is the case with universities.

44. The reader of the above figures will no doubt be conscious of how small a proportion of the disclosures to CPDL of possibly-patentable material, even those from applied research laboratories, are actually able to find their way into commercial use and he may be wondering how much expenditure of effort and public funds the evaluation, patenting, patent maintenance, development, promotion, licensing and administration of this material deserves. In seeking an answer to this question it seems important that it be approached not from the viewpoint of how much royalties do the inventions earn but, far more importantly, of how much are the *users* of the invention, i.e. the Canadian public, benefited. As a broad generalization CPDL royalty charges average about 3 to 5 per cent of the licensee's selling price. (In certain circumstances they can be much lower or much higher). Thus for every dollar of royalties CPDL receives it may be assumed that about twenty-five dollars of business has been generated at the manufacturing or processing level. As at 31 March 1968 CPDL's total earnings from royalties since its inception were $3,392,918, and this suggests that the proportion of the patentable arisings of Canadian government and university research which has been handled by CPDL has generated a total of about $85,000,000 of business. In 1967-68 CPDL's total revenue from royalties was $311,058 indicating business generated was in the order of $7,750,000. It is not possible to estimate how much the use of the products resulting from the manufacture or use of the inventions contributed further to the economy.

45. Shortly after CPDL's incorporation in 1947 the National Research Council of Canada transferred its patent fund of $296,199 to CPDL in exchange for shares. With this working capital the Corporation has since been able to operate—without further expense to the public—from the revenues received from inventions it has licensed. Meantime CPDL has paid out a total of $162,000 in awards to public servants in accordance with government regulations; has borne the costs of invention evaluations, patenting, patent maintenance, assertions and litigations as necessary; has invested $806,000 in the development of inventions and has paid the costs of general CPDL operations and administration and, as at 31 March 1968, the Corporation had a favourable balance on hand of $923,289.

46. Although this record of achievement is probably satisfactory CPDL is conscious that despite its best efforts at least two-thirds of the inventions in its inventory remain unlicensed. There is no doubt that a large proportion of these as yet unlicensed inventions just do not have the intrinsic qualities necessary to compete successfully in the market place. On the other hand it seems not unlikely that a higher proportion of the inventions than at present might find its way, via industry, into public utilization if CPDL could find better combinations of advertising and of identifying the potential and encouraging the utilization of these publicly-produced inventions. To this end CPDL will continue to search, experiment and to adopt those techniques and procedures which appear to be more effective and economically beneficial to the public interest.

ANNEX "A"

DISCLOSURE IN CANADA OF PATENTABLE MATERIAL

The following is the text of a letter despatched by Canadian Patents and Development Limited in June 1967 to all federal departments and agencies conducting technical research or development and to the five provincial research organizations and the seventeen Canadian universities with which CPDL had Agreements to handle their arisings of inventions:

"An extract from the Report of the (U.S.) President's Commission on the Patent System, 1966, says:

"Agreeing that the patent system has in the past performed well its Constitutional mandate 'to promote the progress of...useful arts,' the Commission asked itself: What is the basic worth of a patent system in the context of present day conditions? The members of the Commission unanimously agreed that a patent system today is capable of continuing to provide an incentive to research, development, and innovation. They have discovered no practical substitute for the unique service it renders.

"First, a patent system provides an incentive to invent by offering the possibility of

reward to the inventor and to those who support him. This prospect encourages the expenditure of time and private risk capital in research and development efforts.

" 'Second, and complementary to the first, a patent system stimulates the investment of additional capital needed for the further development and marketing of the invention. In return, the patent owner is given the right, for a limited period, to exclude others from making, using, or selling the invented product or process.

" 'Third, by affording protection, a patent system encourages early public disclosure of technological information some of which might otherwise be kept secret. Early disclosure reduces the likelihood of duplication of effort by others and provides a basis for further advances in the technology involved.

" 'Fourth, a patent system promotes the beneficial exchange of products, services, and technological information across national boundaries by providing protection for industrial property of foreign nationals.'

"We in CPDL receive disclosures of patentable or thought-to-be-patentable material flowing from publicly-financed and publicly or institutionally conducted research and we file for patent on all which we assess as being patentable and worth the costs. We are very conscious of the worth of the patent system and thus of the benefits to Canada (and to the researchers themselves) of researchers disclosing their patentable or possibly patentable discoveries *first* into the patent system.

"We are aware, on the one hand, that significant amounts of patentable material originating from Canadian research have been published, without prior disclosure into the patent system, in open publications with wide international circulation and much of the potential benefit to the Canadian economy has been lost. On the other hand, we suspect that considerable amounts of patentable material are not being disclosed at all by researchers.

"Or studies lead us to conclude that motivation of researchers to disclose their discoveries into the patent system is divided between self and altruistic, e.g. patriotic interests, and that the self-interests are dominant. They comprise a mix of psychological and economic motivations. Thus we think an exhortation to researchers to disclose their discoveries first into the patent system should begin by appealing to their self-interests.

"We consider the most cogent arguments to be:

—by disclosing first into the patent system the researcher gains a large international audience (like the monetary system the patent system is world-wide) *additional* to the general readership of scientific journals and proceedings without penalizing freedom to publish also through these channels.

—the searches through national Patent Offices by those who are seeking to obtain patent on behalf of the researcher usually furnish him with valuable information about directly associated work in his field.

—the financial awards which may be granted to inventors under provisions of the Public Servants Inventions Act are substantial.

—unless patentable discoveries made in Canada are patented by Canadians much of the potential for economic benefits to Canada is lost. It is therefore a patriotic duty of Canadian researchers to disclose their patentable discoveries first into the patent system.

"We think large numbers of researches are unaware of these arguments; and we believe it to be much to their own as well as to national advantage that they do know of them. This letter is earnestly to solicit your assistance in conveying these thoughts onwards to your researchers, as directly and as frequently as suitable opportunities will permit."

First Session—Twenty-eighth Parliament
1968

THE SENATE OF CANADA

PROCEEDINGS

OF THE

SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*
The Honourable DONALD CAMERON, *Vice-Chairman*

No. 8

WEDNESDAY, NOVEMBER 6th, 1968
THURSDAY, NOVEMBER 7th, 1968

WITNESSES:

Science Council of Canada: Dr. Omond M. Solandt, Chairman; Dr. Roger Gaudry, Vice-Chairman, Rector of the University of Montreal; James Mullin, Secretary and Dirk Elbert Leo Maasland, Science Advisor.

APPENDIX:

8.—Brief submitted by the Science Council of Canada.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29341—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday, September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

29341—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate

MINUTES OF PROCEEDINGS

MORNING SITTING

(*First Session*)

WEDNESDAY, November 6, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, MacKenzie, Thompson and Yuzyk—12.

Present but not of the Committee: The Honourable Senator J. J. MacDonald —1.

In attendance:

Philip J. Pocock, Director of Research (Physical Science).

The following witnesses were heard:

SCIENCE COUNCIL OF CANADA:

Dr. Omond M. Solandt, Chairman;

Dr. Roger Gaudry, Vice-Chairman, Rector of the University of Montreal.

(*A curriculum vitae of each witness follows these Minutes.*)

At 1.00 p.m. the Committee adjourned until 8.00 p.m. this day.

EVENING SITTING

(*Second Session*)

The Committee resumed at 8.00 p.m., the Chairman, Senator Lamontagne, presiding.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Bourget, Cameron, Grosart, Hays, Kinnear, MacKenzie, Thompson and Yuzyk—10.

In attendance:

Philip J. Pocock, Director of Research (Physical Science).

The morning witnesses were further questioned together with the following persons:

SCIENCE COUNCIL OF CANADA:

James Mullin, Secretary and Dirk Elbert Leo Maasland, Science Advisor.

(*A curriculum vitae of each witness follows these Minutes.*)

At 10.00 p.m. the Committee adjourned until 10.00 a.m., Thursday, November 7th, 1968.

MORNING SITTING

(Third and final session)

THURSDAY, November 7, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear and Yuzyk—8.

Dr. Omond M. Solandt, heard at the morning and evening sittings on Wednesday, November 6th, 1968, was further questioned.

The following is printed as an Appendix:

8.—Brief submitted by Science Council of Canada.

At 12.30 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Solandt, Omond M., (O.B.E., M.A., M.D., D.Sc., LL.D., F.R.C.P., F.R.S.C.). Born in Winnipeg, Manitoba. He obtained a B.A. in Biological and Medical Sciences at the University of Toronto in 1931. He spent the next two years in post-graduate research under Dr. C. H. Best in the Department of Physiology, Faculty of Medicine, University of Toronto, and obtained an M.A. He took his Doctorate from the Faculty of Medicine in 1936 and was awarded the Gold Medal. He also played on the senior intercollegiate football team. Following graduation from the Faculty of Medicine, he spent a year in research at Cambridge and a year as an intern at the Toronto General Hospital. In 1939, after post-graduate work at the London Hospital, he received the M.R.C.P. (London) and then returned to Cambridge as a lecturer in Physiology and a member of the teaching staff at Trinity Hall. Shortly after the outbreak of war, he was appointed Director of the Southwest London Blood Supply Depot and continued in that capacity until January 1941. He founded the Medical Research Council's Physiological Laboratory at the Armoured Fighting Vehicle School at Lulworth, and became actively engaged in research concerned with tank design and the physiological problems peculiar to tank personnel. In 1942, he turned from medical research to the then new field of operational research and formed the Armoured Fighting Vehicle Section of the Army Operational Research Group. The following year, he was appointed Deputy Superintendent, Army Operational Research Group and in May 1944, Superintendent. He joined the Canadian Army in February 1944 and left the Army in 1946 as a Colonel. In September 1945 he was sent to Japan by the War Office as a member of a mission to evaluate the effects of the atomic bomb. Dr. Solandt returned to the Department of National Defence in Ottawa in 1946 to begin planning for a permanent defence research organization in Canada. This work resulted in the formation of the Defence Research Board in 1947. Dr. Solandt became the first Chairman of the Board and the scientific member of the Chiefs of Staff Committee and Defence Council. In 1956, he left the Defence Research Board to become Vice-President, Research and Development, of the Canadian National Railways. In 1963, he left the CN to become Vice-President, Research and Development, and a Director of The de Havilland Aircraft of Canada, Limited, and Hawker Siddeley Canada Ltd., and Chairman of the Board of DCF Systems Limited. In 1966, he left these positions to become Chairman of the Science Council of Canada and Vice Chairman of the Board of The Electric Reduction Co. He was also a Director of the Huyck Corporation and of EXPO 67. Dr. Solandt was awarded the O.B.E. in 1946, and the U.S. Medal of Freedom with Bronze Palm in 1947. He received the honorary degree of D.Sc. from the University of British Columbia in 1947, from Laval University in 1948, from the University of Manitoba in 1950, from McGill University in 1951, from St. Francis Xavier University in 1956, from Royal Military College in 1966, and from the University of Montreal in 1967; and, an LL.D. from Dalhousie University in 1952, and from the University of Toronto in 1954. He was elected a Fellow of the Royal Society of Canada (Section III) in 1948, and an Honorary Member of the Engineering Institute of Canada. In 1956 he was awarded the Gold Medal of the Professional Institute

of Canada and in 1961 he received the Civic Award of Merit from the City of Toronto. He was President of the Canadian Operational Research Society from 1958-60 and a Governor of Sir George Williams University, Montreal, from 1957-63. He was formerly a Governor of The University of Toronto and of the Arctic Institute of North America, and President of the Royal Canadian Geographical Society. He is at present a Trustee of the Mitre Corporation, Boston, a Director of the Canadian Corporation for the 1967 World Exhibition; a Fellow of the Royal College of Physicians in London, and was elected Chancellor of the University of Toronto in 1965. Dr. Solandt was a member of the Western Team at the Conference of Experts to Study the Methods of Detecting Violations of a Possible Agreement on the Suspension of Nuclear Tests, held in Geneva in 1958. Dr. Solandt has a wide variety of interests, including flying and radio. He secured a commercial radio operator's license before entering university and worked as an observer with the Ontario Provincial Air Service. He is married to the former Elizabeth McPhedran of Toronto and has three children: Sigrid, Andrew and Katherine. He is a member of the St. James's Club, Montreal, the University Club, Montreal, the Rideau Club, Ottawa, the Athenaeum Club, London, England, the York Club, Toronto, and of Bloor Street United Church in Toronto.

Gaudry, Roger, D.Sc., F.R.S.C. First lay rector of the University of Montreal, Dr. Gaudry was born in Quebec in 1913 and educated at the Pensionnat St-Louis de Gonzague and the Petit Séminaire de Québec where he obtained the Bachelor of Arts degree of Laval University in 1933 and the Governor-General's Medal. In 1937 he received the degree of Bachelor of Applied Sciences from Laval University. For three consecutive years he was awarded the Price bursary for being first in class. Appointed Rhodes scholar in 1937, he spent two years in research at Oxford University. He received the Doctor of Science degree from Laval in 1940, became Associate Professor of Chemistry in 1945 and, in 1950, a full Professor in the Faculty of Medicine. In 1954 he was named deputy director of research laboratories of Ayerst, McKenna and Harrison, drug manufacturers, in Montreal which were to become one of the most important industrial research centres in Canada. He became director of the laboratories in 1957 and vice-president in 1963, continuing to direct research until his nomination as Rector of the University of Montreal in June 1965. During his scientific and professional career Dr. Gaudry received numerous distinctions. He was three times named as laureate of the scientific Prize of the Province of Quebec. In 1958 he was awarded the Léo Pariseau Medal of the French Canadian Association for the Advancement of Science. In 1954 he became a Fellow of the Royal Society of Canada, and a lecturer at the Institut scientifique franco-canadien at the University of Paris. He was President of the Canadian Institute of Chemistry in 1955-56 and of the Canadian Association of Rhodes Scholars in 1960-61. He became a member of the Council of the Society of Industrial Chemistry of France in 1960. In 1962 he became a member of the Defence Research Board and of the Governing Board of the National Cancer Institute. In 1963 he was named member of the National Research Council. The Corporation of Professional Chemists of Quebec named his honorary life member in 1964 and he became an honorary member of the Society of Industrial Chemistry of France in April 1965. In October 1965 he

received the medal of the "Anciens de l'Université Laval". Dr. Gaudry is the author or co-author of about 90 scientific papers dealing mainly with organic and biological chemistry.

Mullin, James. Born Maybole, Ayrshire, Scotland, November 4th 1939, Education: Primary and Secondary Schooling in Maybole (1944-58) University of Glasgow, Glasgow, Scotland (1958-62). Degree: Honours B.Sc., in Mathematics and Natural Philosophy. Conferred July 1962. Experience: 1962-67—Atomic Energy of Canada Limited Chalk River Laboratories, Chalk River, Ont. —Reactor Physicist (1962-1964)—Scientific Administrative Officer, Physics Division (1964-1967)—Administrative Assistant to Director, CRNL Research (1967) 1967-present. Secretary, Science Council of Canada. Publications: AECL Reports and Translations, and contributions to AECL's ING Proposal only.

Maasland, Dirk Elbert Leo. Born 24 September 1934. Gorinchem, the Netherlands. Primary and Secondary education in Den Helder, the Netherlands. Undergraduate education (Candidaat) at Wageningen Agricultural University, the Netherlands (Drainage and Irrigation). M.Sc., Colorado State University (Soil Physics), 1961. Ph.D., Colorado State University (Civil Engineering, Hydrology), 1964. Employment: Appointed Science Advisor, Science Council, July, 1968. Project Officer, Water Resources Study, Science Secretariat, Privy Council Office, June 1967—July 1968. Assistant Professor of Civil Engineering, University of Windsor, Windsor, Ontario, 1964-1967. Junior Research Engineer, Dept. of Civil Engineering, Colorado State University, 1963-1964. Registered Professional Engineer in the Province of Ontario. Member of the International Association of Scientific Hydrology, Member of the International Association of Hydraulic Research, Associate Member American Society of Civil Engineers. Co-Author Science Secretariat Special Study No. 5, Water Resources Research in Canada and author of several publications in the field of hydrology.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

MORNING SITTING

(*First session*)

Ottawa, Wednesday, November 6, 1968.

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, I will not spend too much time introducing our guests today, Dr. Solandt and Dr. Gaudry, and their colleagues from the Science Council, because this is the third time they have appeared before the committee. I remember that the Science Council appeared for the first time back in March to give us their general views about science policy; then at a later date they again appeared before us to discuss satellite communications. Today they come before us to discuss their internal operation, of course, but mainly to discuss the report they prepared in the course of this year and published last week, entitled *Towards a National Science Policy for Canada.*

This report deals specifically, and perhaps more directly than other presentations we have received, with our terms of reference. We are pleased indeed to have the benefit of the advice of the Science Council. We understand, of course, that their main purpose in producing this report was to advise the Government, but as a by-product they are also advising part of Parliament, namely the Senate. We are grateful indeed that Dr. Solandt and Dr. Gaudry have accepted the invitation to be with us today. I understand that Dr. Solandt will make a statement to initiate our discussion, and then we will proceed with the usual question period.

Dr. Omond Solandt (Chairman, Science Council of Canada): Thank you very much, Senator Lamontagne. Might I say how pleased we were to be invited to return to the Senate committee. I feel that this is a very important forum for discussion and that it is of the greatest importance that we should try to convey to you our ideas so that you will have them together with the ideas you get from other sources in making your final report. If I may repeat what I said before, I keep hoping that you will never make a final report, and that you will become a continuing committee, because I think the problems we are dealing with are not the kinds of problems that can be solved once and for all; they are problems that we live with, and because it is such a rapidly changing world no solution will be the best solution for very long.

We have for discussion today both the report on national science policy and a brief that was prepared especially for this committee and presented to you, which follows the pattern of briefs you have invited from other groups. Senator Lamontagne has suggested that we might deal with the brief first.

I do not intend to make any long presentation of the brief because it is really self-explanatory, and I hope that you have had time to read it. It is quite short. Before inviting questions on the brief I would like to tell you that last Friday the Prime Minister announced the formal separation of the Science Council staff from the Science Secretariat. The two had been operating more and more as separate entities for the past many months, and in mid-September Dr. McTaggart-Cowan joined the Secretariat as Chief of Studies in the Secretariat, and in effect began to run the Science Council staff as a separate entity. Effective with the separation which took place on Friday, Dr. McTaggart-Cowan has become the Executive Director of the Science Council and will be directly responsible for running the Science Council staff, which is now quite separate from the Science Secretariat.

In order to avoid the necessity of changing the Act immediately—and there is no great

need to—the Science Council staff will continue to be supported financially by the Privy Council office. I was going to say administratively, but it would not be effectively administered by the Privy Council office; our act provides that any department of government can, when authorized by the Governor in Council, supply staff for the Science Council, so all this means is that the Privy Council office will be supplying the administrative existence for our establishment, but we will be operating quite separately.

Perhaps I might ask Dr. McTaggart-Cowan to stand so that you will all recognize him. I am sure you will see more of him as the head of our staff. He will be directing the main work that is done for the Science Council.

The brief that was prepared for you will require some amendment to account for this change in organization, but I think you can see that the amendments will be very simple; some of our operating procedures will be simplified, that is all. It will not make a great deal of difference in the way we have operated; the people we have doing the work are still the same people; the method of operation will be very similar. We hope to and expect that we will maintain very close liaison with the Science Secretariat, which remains in the Privy Council office. We are looking forward to moving all our own staff into one place. At the present time we are widely scattered. We hope to move sometime in December and that many of the Science Secretariat staff will be co-located with us, which will greatly facilitate this continuing co-operation. I think that is all I need say on the brief.

I might perhaps go into Report No. 4, *Towards a National Science Policy for Canada*, in a little more detail, partly on the assumption that you may not all have had time to read it, and partly to make sure that in the ensuing discussion we are all starting from the same base.

As you probably know, apart from our two annual reports, which did contain some specific recommendations on general science policy, the previous reports of the Science Council and Science Secretariat have been limited to fairly narrow fields—physics, space, psychology and so on. These earlier reports consisted primarily of inventories of what was going on in Canada, and then went on to describe in a little more detail recommendations for policy, or at least some of the reports did in these rather narrow fields. But this report that we are now considering has a much broader scope. It is, of course, based on the knowledge that we accumulated in the preparation of the other reports and on a good deal of knowledge of what goes on in Canada that has been accumulated for reports that have not yet been published, because we still have quite a few studies in progress and several reports nearing completion. However, we felt it would not be wise to continue delaying the publication of the basis for a general policy until we were sure we knew every detail about what was going on in science in Canada today, so this is our first effort at outlining the basis for a general science policy.

Really, the basic message of this report is one that I am sure is familiar to many of you already, and it is the basis for most discussion about science policy in the scientific community now. It is fundamentally the idea we are now in a period of transition from what might have been called, to oversimplify it, the period in which we thought of science primarily for science. That is, scientists were working primarily to enlarge man's knowledge about his world and his environment and the effects of this scientific knowledge in the economy and society were important but were not a primary concern, certainly, of scientists.

It seems to us in the Science Council—and, I think, to most people—that we are now entering a new phase in which, as expenditures for science increase and also as the possibilities for using science to solve economic and social problems become more obvious and more important, science policy, at the national level, must be concerned far more with how we use science to solve social and economic problems, rather than with how we develop science.

In emphasizing this change in view one must, of course, always keep reiterating that we can only use science for social and economic problems when we have a thriving and competent scientific community in the country. The fact we are now able to talk about the use of science for social and economic goals is a tribute to the science policy we have pursued in the past, because Canada has, particularly with the leadership of the N.R.C. and the universities, built up a very firm base for its scientific community, and in changing the emphasis we must be very sure

we do not weaken that base. The base must continue to expand and to grow.

So, although this report emphasizes the applications of science, in the report we repeatedly put in the reminder that because we are talking mainly about social and economic applications of science, this does not mean that we should forget the need for the support of basic research—of what we have called here "Little Science", curiosity-directed research. Most of this will be in universities, but we do not visualize it, by any means, all taking place in universities. I want to emphasize that point.

At this stage it might also be worth emphasizing another point made several times throughout the report, although very briefly. It is a curious thing that when I read a report like this I always find that I tend to remember things said at the greatest length, whereas some of the most important things are said in one sentence. This is why I want to emphasize this point, and maybe the easiest way is to read one sentence from the first paragraph of the summary, where it says:

> It should also be noted that the action proposed has far-reaching implications for the development of the social sciences and the Council would support all efforts to promote expansion of the nation's activities in these sciences.

I want to emphasize and underline that statement, because this report deals primarily with the use of the natural sciences and engineering, though it repeatedly mentions the social sciences; but in many of the areas where we have proposed action, it would be most unwise to have action by the natural sciences and engineering without parallel and closely co-ordinated action in the social sciences. This may well be a subject the committee would want to discuss further.

At this point I should say that many of the authors of the report are here today. There are so many I think it would be unfair to identify any one, and it would take too long to identify them all. This report has gone through many drafts, and there have even been several reports that have come as sort of offshoots of this that will be published separately later, some of which I will mention. In looking at the problems of writing a report of this kind, we were immediately struck by the fact that if you are going to advocate the use of science in achieving national social and economic goals, you have to define your national goals. We could not find any definition of "national goals," other than the definitions of economic goals which were made by the Economic Council in one of their early reviews, and which they have up-dated and commented upon in subsequent reviews. These economic goals, I think, have been very widely accepted.

I have been very interested on two or three occasions, when speaking to small groups about national goals, to note that many people said they had never thought before a nation had any goals other than economic ones, and that they had thought the statement by the Economic Council really covered national goals. I am sure no one here would feel that way.

I think that we may be criticized—I am surprised we have not been yet—for stating national goals, because many people say that scientists are not the best qualified people to state national goals, and I would completely agree with that, but somebody has to start, and I would hope that this statement on national goals might provoke some discussion and some refinement and improvement in the idea of having extensively defined national goals, because I think they are fundamental to developing national policy in almost any field.

Another thing that is well worth pointing out in the field of national goals is that as we have stated the goals here, many of them are at least mutually conflicting, if not actually mutually exclusive. This is true even of relatively simple and widely accepted economic goals, because you have only to look at the problems of a high rate of economic growth and reasonable price stability versus full employment. You cannot have all or both of them, so what you have to do is try to have the best mix.

This is true of many of our stated national goals. You cannot have them all at once. You have to decide to which you are going to give the greatest importance and priority. This is why I think it is necessary that we start stating them and talking about them, and deciding wha kind of a mix we want to have.

I would also say—this is not expressed here—that I have a very strong view with respect to a definition of national goals. This attempt to define the kind of country that Canadians want to live in is probably one of

our most important national problems, because, as I see it, if we are to remain an economically viable and reasonably prosperous, happy, and successful country we have to have in Canada a way of life which is on balance more attractive to our young people than the way of life in the United States. In saying that I want to emphasize that I do not for a moment suggest that we want to have in Canada a way of life in which we just say we will do exactly the same as the Americans, but we will do it better. I am convinced that we can have a way of life which is quite different from theirs, which has quite different emphases, but which is more attractive to us than theirs. We do not want to meet them head on in competition. We want to "do our own thing," to use modern slang, and to do it well and in the way we like to do it.

In this context I feel that this is an area in which we can most effectively use our bicultural background. Instead of looking upon our bicultural background as a handicap I think we should look at it as a potential asset. If we can mold our biculturalism into the mix of life, or that which makes up the mix of life in Canada, it will be an asset, and will give us a distinctive way of life and culture in Canada which will not only retain our good people but attract bright people from other countries.

I do not think I will go into more detail on national goals. As you can see, we have classified the mix of national goals into six groups, which are:

- National Prosperity;
- Physical and Mental Health and High Life Expectancy;
- A high and rising standard of education, readily available to all;
- Personal freedom, justice and security for all in a united Canada;
- Increasing availability of leisure and enhancement of the opportunities for personal development; and
- World Peace, based on a fair distribution of the world's existing and potential wealth.

So much for national goals. Although they are in a way incidental to our policy report, they are really the basis upon which the policy report is founded, so I hope you will consider them carefully.

We have given a very brief outline of past trends in funding research and development in Canada. In this you will see particularly the very slow growth of Gross Expenditure on Research and Development. I am not sure whether it is safe to use the abbreviation because it reminds people of other things, but that expenditure as a percentage of gross national product has changed—and this is at page 21 of the report—from 0.95 per cent of G.N.P. in 1957-58 to 1.31 per cent in 1966-67. In between it has had its ups and downs. This table shows in a general way, that although our expenditure on research and development has been increasing, it has not been increasing very rapidly.

One of the other important lessons in this section is contained in Table 2 at the bottom of page 21, which shows that Canada has been putting about 22 per cent of research expenditure into basic research, 41 per cent into applied research, and 37 per cent into development. The comparable figures in the United States, which are given on the next page, show that they put 12 per cent into basic research, as opposed to our 22 per cent; 22 per cent into applied research, as opposed to our 41 per cent; but 66 per cent into development, as opposed to our 37 per cent. This indicates that the United States has, as I think everyone who has studied the matter will agree, a better balanced mix, because basic research is relatively cheap, applied research is more expensive, and development is the most expensive of all. So, if you are carrying on from research and development to effective use then your expenditures ought to increase steadily as you go up the scale, and our expenditures on development have dropped very sharply, and it is apparent that our very high expenditure on research is not a real one; it is high just as a percentage of the total, because our expenditure on development is low.

In Section 5 on page 23 we deal with a general consideration of the organization of science and federal support programs. There are one or two recommendations that are quite concise, that I think are worth reading. First, on page 23:

> It is recommended that in future every new research or development activity be critically examined at its outset to identify the appropriate organization to carry through the project to its final conclusion. For extensive programs that encompass

many individual projects, the distribution of these projects among the sectors of the economy must be carefully considered. Such a procedure may well lead to the universities and industry performing a larger share of the research and development in Canada than has occurred in the past.

This is an idea that we have put in previous reports, when there has been in the past a tendency for whatever agency could most readily get the money to undertake the research without any careful thought being given as to where it could be most effectively done.

The recommendations on page 24 are also important. They have to do primarily with the support of industrial research. We say:

> It is recommended that the Federal Government
>
> (a) support Canadian industrial enterprise by improvement and expansion of existing R&D incentive programs, by simplifying where possible the administration of the programs, and by deliberately increasing the share of management responsibility placed on the companies involved;

Basically, on looking at the incentives it seems that they are doing a good job, but this is a very complex field. We had a most interesting discussion of it with Dr. Horning, the President's Science Adviser in the United States, last week. They were particularly interested in our incentives, and our successes with them.

The next recommendation is that the federal Government:

> (b) further encourage industrial involvement by contracting out Federal programs where participation is likely to increase the technological or innovative capacities of the companies concerned. The underlying objectives should be to upgrade the overall capabilities of those involved, and ultimately to develop self-supporting research organizations in Canadian industry;
>
> (c) through its mission-oriented departments actively seek to promote industrial and university work in support of each mission as well as responding to initiatives from the private sector;

and then, finally, we recommend that the Government should use its procurement contracts to upgrade the competence of industries.

These are all things which are now done to some extent, but in respect of which we are recommending that more should be done.

We have put in one caution further down, that I know will bring joy to the heart of at least the President of the Treasury Board. It is that:

> Firstly, the federal Government cannot be expected to be the sole source of funding of all research and development; if industry is to profit from this scientific activity, then there is an obligation on industry to make substantial investments of its own funds in research development and innovation.

Another recommendation here—it may not look important, but many of us feel it is quite important—is that scientific and contract programs proposed be intended as "spurs to the successful, not as crutches to the failing." There has been, in the past an unfortunate tendency to feel, on the part of some Government officials, that they should use the money available to them to support struggling industries rather than to further support successful industries, and while this is a natural attitude, it certainly is not always the best way of spending the money. We should in many cases have the courage to reinforce success, so that some companies in Canada can become outrageously successful and profitable.

On page 26 there are a series of recommendations about the status of research and development within government. These are faily lengthy so I will not take the time to read them, but I would like to point out the important thing behind these is the idea that all federal Government scientific organizations should be mission-oriented and should be engaged principally in applied research and development. This means that Government agencies that are mission-oriented will inevitably have to be quite flexible in organization and funding, because we are beginning to see in Canada something that besets other nations, particularly Britain at the moment, and that is the fact that a good mission-oriented organization will get first-class results for a good many years. But when the organization is successful in accomplishing its mission, the importance or priority of its mission

becomes less, you find the organization gradually becoming a more fundamentally oriented research organization with no real sense of mission and no vital role in national affairs. We have to find ways of continually checking, as we said previously, and have suggested the idea of a technical audit to look over Government programs to make sure that they are still relevant, important and rank high enough on the priority list of national needs. I think this is particularly important at the present time, when the federal Government finds itself short of money that can be allocated to new projects. We must not get into the trap of continuing everything we are doing just because we are doing it and refusing to start new projects because we are short of money.

Even if we have no more money in a given year it is almost certain that some old projects should be stopped and replaced by some new projects that show greater promise. This is a real problem in managing science anywhere, but it is a particular problem in the Government.

I think I will skip over the rest of that section and go to Section 6, "The Concept of Major Programs" which is really the heart of our report. We have, as the result of discussions that have now lasted nearly 18 months, come quite firmly to the conclusion that the best way of ensuring healthy growth of science in Canada and particularly as the total scientific expenditure grows, is to make sure that more of it is devoted to projects of national economic and social importance. The best way of achieving this is by planning a series of major programs which are designed to achieve specific and defined national goals and then carrying these programs right through to completion. As outlined here, our concept of a major program is that it includes every element in the whole process of innovation right from fundamental research through applied research development to production and use of its hardware or to testing and adoption if it is a new service. Such a program will obviously be multi-disciplinary in the sense it will involve many scientific disciplines including, in nearly every case, social sciences. It will involve every segment of the scientific community. Some parts will be done in Government, some in universities and some in industry. The emphasis must always be on trying to involve as wide a group of the scientific community as possible and on pushing through to a successful conclusion and recognizing that particularly in the mission oriented projects, the pay-off comes from the application of the new knowledge in effective use and that it is really a waste of time doing the work unless you push it through to completion.

On page 31 there are listed criteria for selecting major projects. I will not go through those in detail. Most of them are quite familiar to you. The important problem in connection with major programs is to decide how best to organize them and on looking at the problem carefully we have decided that if there is to be an effective major program there must be some central initiating and coordinating organization. In most cases we see these organizations operating within the federal Government, although there will be cases where this will not be the best way of dealing with it and we should be quite flexible in our approach to it. Where the responsibility lies with a single Government department, the problem is quite easy and in the case of our water resources research report, which I was going to refer to later, we have for instance recommended the control or guidance of a major program in water resources by a committee, an advisory committee within the Department of Energy, Mines and Resources which has the primary responsibility in the federal Government. In many other cases I think it will be necessary to establish a separate organization to head up a major program. We recommended this in the case of a space program and we have reviewed our recommendations since and see no reason to change it. The space problem is different than water, because space involves many different departments, each one operating a departmental space program, but none attempting to put them together into a national space program. Well, we come to look at specific applications of this idea of major programs. We have already recommended two major programs, space and water resources.

We have emphasized in this report that there are already in existence some activities that would certainly qualify as major programs. Probably the most readily identifiable and important one is the atomic power program, which really meets virtually all our criteria as an important Canadian major program in science.

On page 38 we have suggested four important fields in which we feel major important programs should be started very soon—transportation, urban development, computer applications, and scientific and technological aid to developing areas of the world. We have chosen these four on the balance between their importance to Canada, the possibility of doing something of real importance in these fields, and the interests of people in having something done. The plan of the Science Council is to start immediately. In fact we have started in some of these areas to define major programs much more precisely. The discussion of these four areas that we have put in this report is far too diffuse to enable anyone to hire somebody and say, "Start work on this program immediately." We are hoping that in the next few months, certainly in less than a year, we will be able to make specific recommendations in each of these areas which will be sufficiently precise that they can be picked up and converted into actions.

In addition we have listed a series of other areas that need consideration quite quickly, but to which, as far as the Science Council's immediate program goes, we have given slightly lower priority than the others, although, as you will see, some of them are just as important and just as urgent. This may be something on which the committee will have views. They are listed on page 46.

In the field of health care delivery systems, as I see it there is need for widespread application of science, particularly systems science, to try to see if we cannot find a better way of delivering health care to the population—health care that is of as good quality as we get now, and in fact hopefully of improved quality, but at much less cost. This is an area in which we have set our goals as perfection and have not really looked at productivity, and we must. The same applies to educational systems, although we have not listed them here.

Then there is the economic development of Canada's north, the development of energy sources, integrated resource management, oceanography and marine and undersea technology, and weather prediction, modification and control.

Then, of course, we have noted that many existing programs really qualify in different ways under this general heading of major programs and should certainly be continued.

Finally there are two sections with which I will deal very briefly, but which I think may well lead to quite extensive discussion. One is that of manpower. Very briefly we have said it looks to us as if there will be enough qualified manpower to do the things we forecast. We do not see any major over-supply of manpower. This is something you might want to discuss.

We have looked very cautiously at what the expenditures might be. I may say that this section on expenditures has been re-written maybe 20 times and gets milder and less precise every time, but this is something that you would probably like to discuss.

The Chairman: Perhaps we could see all the drafts!

Dr. Solandt: I am afraid you would not have time to read them.

I will not go into any detail here, except I think it fair to say that the majority of the Council are firmly convinced that we will be spending a good deal more than the present target of two per cent of GNP on what could be called research and development, certainly before the end of the century.

Much of this expenditure will be intimately wrapped up in major programs of social and economic importance, and will be justified economically and socially on the grounds of its value as a contribution to this area. For instance, there is a tremendous need for scientific input to regional development programs. This will occupy a great many scientists and may be a big expenditure on science, but no one will think of it as a scientific expenditure; it will have been chosen by governments on the grounds of its needs as part of national policy. So much for a brief review of this report.

In conclusion, I would like to re-emphasize the principal points I made. We need to define our national goals. We need to plan programs for the use of science to help achieve these national goals, and we must be sure that we carry these programs through to effective completion. In doing this we must continue to be sure that these programs not only have a broad base, scientifically, but that they have the support of our political leadership. I would again emphasize that they must contain a very major element of social sciences.

I think that is all I will say by way of introduction.

The Chairman: Thank you very much, Dr. Solandt. Dr. Gaudry, did you have anything to add?

Dr. Roger Gaudry (Vice-Chairman, Science Council of Canada): No, I think I would prefer to wait and answer questions which are asked.

The Chairman: As we go into the question and discussion period we will try as much as possible to separate the operation, role and compositional structure of the Council from the report on national science policy. As I said before, I would propose that we start by discussing the brief presented by the Council.

I understand that this committee met yesterday *in camera* in my absence, when apparently I was designated to ask the first questions. This is the first time it has happened.

Dr. Solandt, on the first part of your presentation I have questions which really fall into two different categories. I would like to ask you a few questions about the process of policy formulation and implementation, and the role of the Science Council in that process. Secondly, I would like also to put to you a few questions regarding the Council's structure and composition.

First of all, for the benefit of the committee, would you describe the present process of science policy formulation and implementation, and indicate the exact role of the Science Council and of other agencies in that process? Would you say, for instance, that the Council's role is more or less limited to advising the Government on long-term goals and programs?

Dr. Solandt: The role of the Council certainly is not limited by statute to this. In fact, the Council has decided itself that it can be most effective in dealing not so much with long-term as with broad strategic goals—and these, of course, of necessity usually are longer term.

We have felt that if we could get a good general framework of policy that was widely agreed to and understood, then the more short-term tactical decisions, if you like, could be readily taken my many different agencies in light of these policies. Hopefully, if the broad policies are understood and widely accepted, then people will try to make their more detailed decisions to conform with these broad policies.

There is nothing in the terms-of-reference of the Council that prohibits it from dealing with short-term problems. The only short-term one we have dealt with was ING, which we were reluctant to take on as our very first project because this, in effect, was asking the Council to reach a decision on a specific problem before it has ever had a chance to discuss the general background. We would feel much more competent to deal with ING now than we felt 2½ years ago, because we are beginning to get a framework, and when we get one, such as is set out here, well established, we could quite easily deal with shorter-range problems, but I would hate to be asked to deal with those on a small scale. Some of them are so big—ING being a good example—that you cannot very well disassociate them from major policy considerations, because if you decide to build ING you tie up a significant part of your resources.

The Chairman: So that in the process of science policy formulation you would limit yourself to broad programs and deal with them in more or less general terms, and let the normal government operation decide as to the details and the carrying out of these programs?

Dr. Solandt: Yes, although as you have seen from the Space Report—and I did not mention that since we last appeared before the committee we have released a report on a major program of water resources research, with a large back-up study on water resources research in Canada by the Secretariat—and these do get down to a fairly detailed level of considering the sub-fields which are of peculiar importance to Canada. And I think that you will see that these two, between them, act as quite a detailed guide for anyone planning a research program in Canada. So, we have gone much further than just push the importance of water resources research to Canada. We have analyzed it in quite considerable detail, and have shown areas within the field which are more important to Canada than other areas.

The Chairman: To come back to my general question, you have nothing to do with the implementation of policy?

Dr. Solandt: No.

The Chairman: Then, in the field of policy formulation, do you consider that at present you are the sole or the main body, or one of the agencies advising the Government?

Dr. Solandt: Yes. I would think that in the field of science policy we are the major agency advising the Government. Policy is, of course, a field in which everybody is free to express opinions, and Government is always influenced, more or less, by opinions that it hears; but I do not think that there is any body that is systematically dealing with science policy in competition with us. Other agencies—such as NRC, Atomic Energy, and Defence Research Board—are dealing with the science policy in their areas, some of which are quite large. However, it is pretty well co-ordinated, because the heads of all these agencies are on the Science Council, and they all a great deal to say about the ideas that went into this report.

The Chairman: Would you say that the Science Secretariat, even under the new arrangement, might be tempted to conduct some kind of similar or parallel operation, so that we will have really two agencies—the Science Council and what will be left of the Science Secretariat in the Privy Council Office—both advising the Government at the same time on the same matters, more or less?

Dr. Solandt: This is a real danger. I think when I was last before the committee I expressed my misgivings about a separation.

This will not be a problem if we are able—as I am confident we will be—to maintain close co-operation and intercommunication between the two bodies, because as Dr. MacKenzie saw it, when he recommended setting up the two—and as I think our experience has shown too—there is a real need for a body within Government to interpret broad policy—well, to advise Treasury Board and departments on whether proposals they have for new programs or actions fit in with the broad policy or not. That is really to interpret, in detail, broad policies.

If the Secretariat confines itself to this sort of work, which I think is its intention—and you will be hearing from the Secretariat, I think, in a week or so—then the two bodies will be complementary, as was envisaged, and they should make an effective team.

The Chairman: Is there not a danger that we could run into a kind of vicious circle, unless there is a series of consultations? Proposals come from the research agencies; they go to Treasury Board eventually, and I am told that Treasury Board at present, at least, is not very well equipped to appraise these programs and projects. Therefore, they go back to the Science Secretariat, which does not have enough staff to appraise these things; so then they go back to the original agency for advice, and we have completed the circle.

Dr. Solandt: Yes, there is this danger, but I think that at this level of detail we must depend more on the competence of the people who are making proposals for research, and that the Treasury Board should limit itself rather more to deciding on the basis of broad national policy considerations how the money should be apportioned between different areas of expenditure, but when you come down to deciding, say, within Fisheries or Forestry which particular projects the money should be spent on then surely the people within Fisheries or Forestry should be the ones best able to make those detailed decisions. I think where they are not able to make them is in the field of deciding what proportion of the total should go to these different fields.

The Chairman: So, you would see the Science Secretariat, as newly organized, as a kind of advising agency more or less on concrete and day-to-day operations, supplementing the kind of wisdom, if any, that Treasury Board has been able to accumulate?

Dr. Solandt: Yes, but I share your apprehension that there is a possibility of actual conflict. I do not mean physical conflict, but—

The Chairman: I hope not.

Dr. Solandt: —there will be rivalry. I am pretty sure that if the two agencies are physically together so that consultation is easy and frequent, they will be complementary rather than competitive, and this is our objective.

The Chairman: Now, once the Council makes a recommendation, which I understand is always public—you do not make any private recommendations?

Dr. Solandt: Not necessarily. We have given no undertaking to make them always public, but this is a point that I have discussed at great length with Dr. Hornig who has had five years, experience in advising the President of the United States. The practice in the United States has been often to give non-public advice to the President or to other presidential advisers. I think the Science Council has to reserve the right to give confidential advice. We have not done that so far, but we can foresee cases where this might be very useful.

The Chairman: But once a recommendation has been made by the Council—let us say, a public recommendation—does the Council attempt in any way to follow it through? Do you make, for instance, on the basis of these recommendations, further representations to the Prime Minister, or the President of the Treasury Board, or a cabinet committee, or is the carrying through of your recommendation left to the Privy Council office or the officials of the Treasury Board?

Dr. Solandt: So far any follow-through has been done by either Dr. Gaudry or myself, or occasionally by other members of the Council, because the Secretariat, being within the Privy Council office, finds itself in a difficult position in going to talk to other Government departments, or going outside the Government.

We have already started campaigns, for instance, to follow up this water resources program in order to try to make sure that the recommendations are fully understood by the people whom we think should implement them, and to encourage them to get on with the job, and to see whether they have any real difficulties or arguments against it. So, I think with the separation of our staff from the Privy Council Secretariat we will do more of this follow-up, but we—

The Chairman: Do you mean follow-up with the Government, or with the scientific community?

Dr. Solandt: Both.

The Chairman: In the sense that with this division you will have more easy access to government?

Dr. Solandt: I think we will, yes.

The Chairman: My next question is: Is the Council involved at any stage in the short term formulation and implementation of science policy? You have already answered this question to some degree, but more specifically are you expected to review, or have you already reviewed, the five-year estimate forecast which the research agencies have to submit to the Treasury Board?

Dr. Solandt: We have not reviewed that, and there is no question but that one of the areas in which we have been very slow in getting started is in this specific examination of objectives. Our idea here is not that we want to . . .

The Chairman: This is covered by your terms of reference?

Dr. Solandt: Yes, we can do it, and, in fact, we have already discussed the mechanism for starting to do it and doing it, but I have in mind here—and I think this can be one of our most important continuing functions—is not looking at specific projects within areas of expenditure, but looking at broad areas of expenditure in order to see that the trends of expenditure are in the right direction and whether the money seems to be reasonably divided between the different segments of the scientific community, and suggesting alterations in emphasis that are needed to meet changing conditions. Until we get to doing this on a regular basis we will not really have completed the cycle of policy advice.

Dr. Gaudry: But here, Mr. Chairman, one problem has been that the statistics as to expenditures on R&D have been too old to permit us to make rather rapid and precise recommendations as to needed changes or trends.

The Chairman: I am not sure that it is really a question of statistics. This is a question of figures which have to be prepared by each agency giving a forecast of what they expect to spend during the next five years.

Dr. Gaudry: You are talking about expenditures by the Government, and we are talking about R&D in the whole country. You have to know what is going on this year in industry—whether it is more than last year, and if so by how much, and so on, and what are the forecasts for next year.

The Chairman: I see. But, you have access to these forecasts as they are made by the research agencies?

Dr. Solandt: Yes. We have not yet studied them, but there is no difficulty about our access to them.

The Chairman: When you want to deal with Cabinet to whom do you go at present—the Cabinet committee, the President of the Privy Council, or the Prime Minister? I know that officially and formally you report to the Prime Minister, but do you discuss the problems of science policy with the Prime Minister or with the President of the Privy Council?

Dr. Solandt: In the recent past we have discussed them with both the Prime Minister and, strangely enough, the President of the Treasury Board . . .

The Chairman: I am sorry; I meant the President of the Treasury Board.

Dr. Solandt: ...because he is the member of the Cabinet committee responsible for scientific and industrial research, and as such is really the principal adviser to the Cabinet on scientific research. Of course, as you know, Mr. Drury, having come from the Department of Industry, has been closely involved.

The Chairman: Your channel is through the President of the Treasury Board at the moment?

Dr. Solandt: Yes, what really has happened on major discussions in the recent past is that the Prime Minister has had a number of discussions and has said: "Now, these are unresolved problems. Discuss them with Mr. Drury, and then we will have another session." This is the way it has been working.

The Chairman: A kind of supreme court arrangement. Now, I would like to deal also with the Council structure and composition. Regarding my first question in this category, do you think there would be more continuity and efficiency in the work of the Council if the Chairman and Vice-Chairman were full-time members, as they are in the Economic Council of Canada? This is no reflection on the way you are performing your duties, gentlemen, but in the light of the experience that you have gained over the past two years...

Dr. Solandt: That is like asking "have you stopped beating your wife?" because no matter how one answers it is bound to cause a little embarrassment. Dr. Gaudry and I, as well as many others, have discussed this very frankly and freely because neither Dr. Gaudry nor I are expected to live forever or to stay in this job forever, so we do not have any real vested interest in it. The dilemma seems to be very straightforward. I do not think there is any doubt whatever that the work of the Council would operate better with a full-time Chairman and probably with a full-time Vice-Chairman. On the other hand, we are horrified by the thought of a permanent Chairman or Vice-Chairman as this, to my mind is very much a job where you want people to guide the policy formation, as opposed to just a working staff.

The Chairman: You can have full-time members, of course.

Dr. Solandt: This is the difficulty in the Canadian scene, that we have not yet built up the tradition that the Americans have of having top-flight people from universities or industry move into government for quite long periods. A full-time person who is only in for a year would not be any better than a part-time, and in fact would not be as good. He has got to come in, I would say, for a minimum of three years and in the formative period, such as we have discussed. Even three years is not long enough. Five or six years is better, but he must be prepared to leave at the end of that time, and ideally he should not be too old so that he can be closely in touch with the future rather than the past. If we could get universities, industry and Government departments to release people like this, it would be the ideal solution. A person like Dr. Hornig has been five years as the President's Science Advisor and resigned as Chairman of the chemistry department at Princeton in order to take the job. He is not going back to Princeton. He was not on a leave of absence. He is just one of 50 or 100 like this in Washington at any given time. I think this is something we must work toward.

The Chairman: This has worked well with the Economic Council, because I remember when I helped to set up that Council. I had long discussions with Dr. Deutsch and he wanted, as you well know, to stay at the university at that time but he finally agreed to come for a period of three years and he then went back. I am sure that this will be more and more possible in the Canadian scene from now on.

Dr. Solandt: I think that Dr. Deutsch is an excellent example of what can be done.

The Chairman: Now, the Council in defining goals and priorities for science policy—I do not want to get involved with the report at this stage—seems to want to put the emphasis on our economic and social problems and I have no quarrel with this, at least for the time being. But given this declared intention of the Council, how can you expect to define satisfactorily economic and social goals and priorities and to identify even in general terms what ought to be the major areas of research in the social sciences if you have no social scientists sitting as full members of the Council?

Dr. Solandt: Let me first say that our aim is not really to seek to solve social and eco-

nomic problems; it is to seek to define how science can best help in solving these, because these problems are not soluble by science alone. They need political and community leadership and all sorts of other things. The simple answer to your question is that I only know of three people who firmly share the view that the Science Council cannot deal with these things without social scientists on it. I think the three I am talking about are here at the table.

Let me go further back. I mentioned before that when the Council act was originally being written it specified that it would deal with the natural sciences and engineering. I was not appointed Chairman at the time, but saw the draft of the act and had this removed. I was unable to get any mention of social science put in, but the act just says "science" so by the act, we are permitted to deal with social science problems. There has been strong resistance by almost everyone consulted to putting social scientists on the Council and I feel quite strongly that one of our really important problems in science in Canada today is to get an effective body for formulating national science policy in the social sciences, as well as in the natural sciences and engineering. We, in the Science Council, have so far merely said that we recognize the importance of social sciences. We want to reach out as far as we can toward them to join hands and make sure there is no gap between the two, but we certainly do not have the membership either on the Council itself or the staff to do an effective job of dealing with social science problems.

As you know, we have been strengthened in this are by two new members, Dr. Dansereau from the University of Montreal and Dr. Kates who is among other things an urban transport authority and much involved in city planning.

The Chairman: I thought that Dr. Dansereau was a former Dean of Science at the University of Montreal. Would he qualify as a social scientists?

Dr. Gaudry: Almost. He is an ecologist and interested in environmental problems.

The Chairman: I know him very well.

Dr. Solandt: These are really people that would be excellent. They are people that bridge between natural sciences and the social sciences, but both of them have the main base in the natural sciences.

The Chairman: You would agree that as you move along in that direction you are likely, explicitly or implicitly, to set priorities for research and development in the social sciences, if your approach and your specific proposals regarding research projects are accepted.

Dr. Solandt: Yes, there is this risk. Specifically, we will merely be pointing out areas in which there is need to do work in the social sciences in connection with programs that we are advocating, but, as you say, if no one from the social science side is outlining priorities from their point of view, our views may prevail just for lack of opposing views.

The Chairman: But apart from the Economic Council which has a different responsibility and operation, is there any agency in the federal field now trying to define priorities in the field of social sciences?

Dr. Solandt: No. We have worked very closely with the Canada Council—

The Chairman: I knew the answer.

Dr. Solandt: We have worked very closely with the Canada Council on support of research in the universities, for instance, but this experience has made it quite clear to us, as I am sure you know well, that the Canada Council is not really constituted for dealing with, nor is it attempting to deal with, broad policy problems in the social sciences.

I recognize that dealing with policy problems in the social sciences is much more difficult than in the natural sciences and engineering, and it is much less attractive to governments because the solution to social science problems nearly always gets you into political fields very directly. I think natural sciences and engineering have been fairly popular because they do deal in rather objective ways with problems that everyone can see and describe.

The Chairman: Wait until you get into pollution.

Dr. Solandt: But pollution is very largely a social problem. That is, the decision as to what amount of pollution we are going to tolerate is a social problem, and the engineering and technical side of pollution is really much easier than the social and economic problems.

The Chairman: I think it was Dr. Gray who was telling us last week that so far as pollu-

tion was concerned it was not so much a question of research but a question of regulation. Would you agree with that?

Dr. Solandt: Yes. But the regulation has to be based on an understanding of both social and economic factors.

The Chairman: I have just one question to ask and then I will end my monopoly. Then, after we have had our coffee break, I will yield to the members of the committee.

Since most of the members of the council representing universities and industry are greatly dependent on Government assistance to finance their research activities, do you think this position of financial dependence inclines them to constitute a lobby for the private sector, or does it frustrate them when they have to appraise and criticize government programs and projects in the presence of public servants responsible for the allocation of grants? In other words, given the role that the council has to play, are you satisfied with the way it is being composed? For instance, is the public sector represented on similar bodies in the United States?

Dr. Solandt: You have a gift for asking difficult questions. But it is a very relevant and very important question.

The Chairman: I am sure members have felt, too, that since we have started this investigation we have seen that the so-called scientific establishment in Canada is relatively restricted, at least in so far as the composition of boards and councils are concerned.

Dr. Solandt: It is very restricted. I might say that this is a field in which everybody will have his own opinion, but I have had quite a lot of experience in this field on both sides of the fence. I would say that in general the people from the universities find themselves in a very difficult position in dealing with Government officials, because they on the one hand would like to be critical of what the Government is doing in many cases, but, on the other hand, recognize the most of their support comes from the Government and, as you say, it is usually the same people who are involved. There is no doubt that this has been a major factor in the operation of the National Research Council.

It might not be out of place to tell a story, since it is now so far back in history and will not affect anybody, but one year in my early days as chairman of the Defence Research Board—which would be 20 years ago now—I suddenly realized that I had had quite a number of members of the National Research Council in to visit me. I got my secretary to check back and I found that over a period of time every member had been in to see me and everyone had come with a special message to say, "Is there not something you can do toward changing the policy of grants to make it more like that of the Defence Research Board?" At that time the policy of the Defence Research Board in respect of grants was more liberal because we were new and had started without some of the difficulties inherent in the other system. I said, "You are a member of the Research Council. Why do you not do something about it yourself?" And the answer would be, "Well, I wouldn't like to rock the boat." Every single member had come in to see me in this connection.

Now the situation has greatly improved, largely because there are more and more people getting involved, but you have put your finger on a very real problem which derives from the small size of our scientific community. The people who are asking for the money are also the ones who are on the committees that might be in a position to be critical.

Let me say also that there is very little lobbying done on committees by the universities or industrial representatives. I think industry in particular tends to be like the Ogden Nash character, who leaned so far over backwards in order to be upright that he fell on his face.

Typically, an industrial member of a committee loses business for his company by being on the committee. That is, if his company is involved in that field. An that is so because he feels he cannot press the claims of his company at all. So many people make real sacrifices by going on committees.

This, again, is the problem of our small size. We cannot get enough good people to find good ones that are just not involved at all. So far as the Science Council goes I would say that we have been just remarkably free from this kind of problem. Would you not agree?

Dr. Gaudry: For one good reason: we do not have any money to allocate.

The Chairman: But the members of the Science Council are expecting money and assistance from other research agencies, and

the heads of these other research agencies are members of the council. They, if not participating actively in the discussion, are at least listening.

Dr. Gaudry: Yes. This is very true. I am the Chairman of the Committee of the Science Council to study support of research in universities. We hope that in the spring we will be able to come up with a report for the Science Council which may lead to a recommendation of a new policy. At that time I may be faced very clearly with this problem, because the people involved in the agencies of the Government may completely disagree with what we recommend. That remains to be seen, but we could be in the position that this will be a risk; but it will be just one more risk to add to those that university presidents now have to take.

The Chairman: You will not have any trouble with this committee, provided you give enough money to the University of British Columbia.

(A short recess.)

Upon resuming:

The Chairman: Who is going to be our first questioner? Senator MacKenzie.

Senator MacKenzie: Mr. Chairman, there are so many questions that grow out of this report.

The Chairman: I understand that now we are trying to focus our attention on the brief and along the line of questions that were put to Dr. Solandt.

Senator MacKenzie: I our meeting *in camera* yesterday I was asked to refer to two or three matters in a general way about the report.

The Chairman: I was proposing this morning, because I regret I was not able to be at the meeting yesterday afternoon—and I thought this had been more or less agreed to—that we would deal with matters referring to the brief at first and then go on to the report.

Senator Grosart: Mr. Chairman, as I was acting chairman during your absence yesterday, the committee agreed, and I think it was a general decision, that it would be almost impossible to separate the two. I am sure Senator MacKenzie knows your wishes in the matter.

Senator MacKenzie: As I was saying, there are so many questions of interest and importance that I hardly know where to begin and still leave some time for the other members of the committee. However, I want to be brief. I would like in the first instance to congratulate the Science Council on one of the major studies which they have proposed, and apparently have done something about because it is here in this batch of material that has been presented to us. The members of the Senate will remember that I think my first intervention in the Senate when I came here was to suggest and recommend that a special or probably joint committee of the Senate and the House of Commons should be established to study our fresh-water resources in Canada. It gives me a great deal of pleasure and satisfaction to know that that is being undertaken and is going on, because I believe this will continue to be a subject of major importance because of the amount of fresh water that we possess, and the potentially growing needs for fresh water on this continent and across the world.

Going on from that, there are two major questions that I want to raise and discuss. The first has to do with the general activities, functions and purposes of the Science Council and about science generally in Canada. My questions about it have been answered in part in the report, but it has been one of my continuing interests and feelings that science is, and must be, concerned with human beings and what happens to human beings as a result of the work they are doing in science and technology, and also how the welfare and lives of human beings can be improved as a result of the work done by the scientists.

I should like to read a passage from page 6 of this report from the United States on the technological assessment seminar, which our Secretariat was good enough to leave with me:

> The third part of the program I would recommend is to direct our technology to our unmet human needs. It seems to me that an increasing proportion of our scientific and technological resources should be applied to alleviating environmental and social problems derived from technology, and should be used towards enhancing our way of life. I am talking about applying science and technology to the attainment of important human values, to enhancing the satisfactions from work, to improving the environment, to rehabilitating natural resources, et cetera.

It was therefore with a great deal of pleasure that I read page 13 of section 3 of Report No. 4, the general framework of policy that the Council has set itself, for the time being at least, and the six goals chosen: national prosperity; physical and mental health and high life expectancy; a high and rising standard of education, readily available to all; personal freedom, justice and security for all in a united Canada; increasing availability of leisure and enhancement of the opportunities for personal development; world peace, based on a fair distribution of the world's existing and potential wealth. I like that very much.

The Chairman: It sounds like a good political platform!

Senator MacKenzie: Or any other platform. As in our debate in the Senate on poverty, I am again persuaded of the platitude that most of our problems exist and continue because of human beings. This is where not only the social sciences may be involved, but where the other areas of the academic and intellectual group in our society could be and should be involved, because I do not think we can achieve the Utopia we desire unless human beings themselves realize the roles they must play and the responsibilities that they must individually accept if those roles are to be achieved.

This is one of the kinds of attitude I have had about the contributions we should expect of our universities. I am delighted that Dr. Gaudry is the chairman of the committee on support for universities, because I know the report he will produce with his committee will be an extremely good one. Despite our Chairman's scepticism, I am not here thinking of financial support alone, although that is essentially desirable, even for U.B.C. I am thinking of the function and responsibility of the universities in our society in dealing with the human problems, which involves not only the natural, physical and social sciences, but the humanities, and philosophy as well I would expect. We will therefore all look forward to this report with a great deal of interest.

I have one or two questions on the universities themselves. The first has to do with the dual role of the Government of Canada agencies in dealing with the universities. One of the responsibilities of the universities is the education of young men and women and their training for professions and in other fields. The other, related to it—although it is perhaps an area of special concern to the Science Council and to government—is the actual research done in the universities by university personnel with university facilities, either at the request or instigation of or in the interests of government agencies and the Government.

In the past the universities have benefited greatly from having this kind of work done. It has not only brought to the universities good young men and women interested in science and research, but has also through their interest and work in those fields produced teachers much better than they could otherwise be. It is in a sense a two-way benefit; it is a very important benefit to and necessity for the universities, but I believe it is also essential and necessary, particularly in the area of basic research, to government agencies, the Government and the scientific community generally.

As science develops and projects increase in complexity, and as the equipment necessary becomes more sophisticated and more expensive, it is of very great importance that the universities should co-operate more than they have done in the past in terms of important, expensive research work that may be expected of them or done within them.

I am encouraged by the fact that in two instances the universities of the western provinces are joining and making available their resources for common purposes in these fields of science. I would hope that this kind of thing would be a subject for discussion, as I am sure it has been, by the Council with the universities, so that more of this can be done, because without it much of the important work can obviously not be duplicated in every university in Canada.

The other point I wanted to raise about the universities has to do with the statistics that we were given by Dr. Gray last week as to the numbers of graduates in science and engineering we were looking forward to within a relatively short period of time in Canada—the jump from about 100,000 to about 300,000. I think you repeat in your report very much the same kind of statement.

You also put on the recrd that it was expected that some 70 per cent of the increase in production of Ph.D.'s and scientists and so on and so forth, would be in the universities. I hope that this will be given further study and consideration, because I am not sure that this kind of balance as between

Government, industry and universities, in terms of trained manpower, is the right one.

After all, apart from the type of research that I have been talking about—that has been done, that is being done, and, we hope, will be done increasingly in the universities—the functions of the universities are to teach and to instruct, and if the universities devote most of their attention to the production and training of teachers to teach teachers, to teach teachers, to teach teachers, I just do not think that is good enough in our society. I think they have to take a much broader responsibility and a broader view of their function and of their work than that. I am proposing, Mr. Chairman, to leave the question of universities for the moment.

I would like to go on and raise, in a specific way, this question that has been of major interest to our committee ever since we began our hearings; and that is, if you like, the chain of authority and responsibility in respect of advice and the implementation of that advice.

I have in mind a practical illustration of this. This has to do with the observatory on Mount Kobau, which you were expecting me to bring forward. I am not an astronomer, I have no particular brief for astronomers or astronomy, but I am concerned with the principles, and I would like, if it can be given us, to know what has happened in this instance.

I have here a statement that the Dominion Astrophysical Observatory was built on Little Saanich Mountain near Victoria after a careful site testing program throughout our nation had established that southwestern B.C. was the best region in Canada for the location of a major observatory. That was done, I do not know how many years ago—80 years ago or something of that kind, a long time ago. Then during the Queen's visit to Charlottetown in 1964 the announcement was made that a major new observatory would be constructed in Canada to revitalize Canadian astronomy. A renewed search, undertaken by Dr. G. J. Odgers, resulted in the selection of Mount Kobau, near Osoyoos as the best site. On this basis the National Advisory Committee to the Department of Energy, Mines and Resources—composed of representatives of all major astronomical centres in Canada, including Toronto, as well as distinguished scientists from related fields, such as Dr. G. Herzberg of NRC—made two recommendations: (1) That Mount Kobau should be the site of National Queen Elizabeth II Observatory; and (2) that there should be established a National Institute of Astronomy on the campus of the University of British Columbia. That project was proceeded with.

Again, I think here in terms of the possibilities of salvage, and the value of their assets in hand is some $4 million, divided as follows: a mirror blank, which apparently is valued at $1.1 million; optical shop equipment, $400,000; engineering design studies, $700,000; site development, including 12-mile road to 6,200-ft. high summit on Mount Kobau, $1.5 million. The site was granted by the Government of British Columbia.

This money was spent, and this project was agreed to and was under way. Then it was halted in midstream, and it is no secret that as a reult of this there is a substantial number of disappointed and disgruntled scientists in western Canada—not only in the field of astronomy—because they do not think this makes sense, to propose a project, to get it under way, to spend a lot of public money on it, and then, without explanation, to drop it. This, as I say, is not particularly sensible.

Now, I am not arguing that this should necessarily be revived. It may be that astronomy has no importance in the Canadian future or on the Canadian scene, but I think it would have been a happier result if whoever was responsible had indicated, as with ING, that the matter was still under study or might be proceeded with at some future date, or something of this kind.

The only encouraging result of all this is that the four western universities are at the present time trying themselves, with their limited resources, to salvage this project, because they believe it is important. They are hoping that the equipment and facilities presently available will not be scrapped, but that they will be retained so that, in due course, if this co-operation becomes effective, some progress can be made in respect of this whole program, and perhaps at substantially less expense than was originally envisaged.

But I come back again to the question of principle. Every little while we find reference made to the Arrow project, which was abandoned. I, personally, at the time felt, and have felt ever since, quite apart from politics, that from the point of view of science, engineering, and technology that abandonment was unfortunate for Canada. However, that project did involve a great deal of money at a

time when money was difficult to obtain, and there may have been justifications on financial grounds at that time. This particular project in terms of money being spent was not a very serious matter in terms of the total moneys being spent on science and research and development in Canada.

So, I come back to the two questions, which I do not necessarily expect the Science Council to answer because I do not think they were involved in it, or responsible for it. But, when advice is given it comes, I take it, from the Science Council—I think we were told this earlier—to the Government in the form of reports, and discussions between the Chairman, the Vice-Chairman and other members of the Council and the President of the Treasury Board, and possibly other interested members of the Government. I can understand the Government's taking that advice because, after all, decisions of this kind have to be made by the Government itself in the light of its own circumstances and decisions, but it would be useful and interesting for us to have the members of the Science Council give us again a statement of their functions as to projects that are developed, and state to whom they go, and what action can be taken about them.

That is all I propose to say at the moment, Mr. Chairman.

The Chairman: Dr. Solandt?

Dr. Solandt: Dr. Gaudry, would you like to say something on this?

Dr. Gaudry: Perhaps I can say something. You have in these reports a scientific and economic evaluation of ING, so the Science Council was involved in ING, but it was involved when it had just been formed, and it was involved in a rather unfortunate manner because it had not yet begun to try to establish the basis of a science policy. We tried to be of help to the Government, but I do not think that we should have been involved at that time because we were too young, and also because our purpose is not very specific in respect of these very delicate questions. Our purpose is to recommend a broad policy within which the Government should be able to make its own decision.

In the case of the telescope, this started long before the Science Council was formed, and we were never asked to issue a statement of policy on that question.

But, it is a fact that as the Science Council exists now there is a problem which has not yet been solved, and that is the problem you raised as to the implementation of the policies of the Council—where do these things go from here?

Senator MacKenzie: Exactly.

Dr. Gaudry: While this has been discussed actively in the Science Council, and between the Science Council and the Government, I do not think that we have yet a very clear opinion as to how it should best be done, who should be responsible for the implementation of the policies once they have been in principle approved by the Government, or even who should be responsible for trying to get these recommendations approved and make part of Government policy once we have issued a policy report or statement.

Senator MacKenzie: I am particularly concerned that, if possible, projects should not be approved and commenced and carried on to some length, and then dropped, unless there are good reasons for doing so. They should not be recommended in the first place. They should not be implemented in part, in the second place.

Dr. Gaudry: That is right.

Senator MacKenzie: I know that human nature, being what it is, and the fact that changes take place so rapidly, may be the cause of this, but it does not look good and it does not smell good in the light of public opinion in any way, shape or form.

Senator Grosart: Mr. Chairman, may I ask a supplementary question? If the Science Council feels it should not take the responsibility for advising the Government on immediate short term science policy decisions, where should the responsibility for that in-put of science into government policy-making be laid?

Dr. Solandt: May I answer your question and also Dr. MacKenzie's by elaborating on the problem of the Queen Elizabeth II Telescope. As I see it, if this problem came up now, with the Science Council functioning reasonably well, the first thing would be to look at Canada's national interest in astronomy.

Senator MacKenzie: I agree.

Dr. Solandt: Why should Canada be in the field of astronomy at all? Is it a concern of

government? is it a concern of industry? or is it a concern of the universities? Having looked at this problem you would then decide, in the light of Canada's defined interest in astronomy, what we should do about it. Now, this was not done.

The Government traditionally has been responsible for astronomy. Frankly, I do not think this makes sense—that is, if you look at it today. It does makes sense historically, and the Canadian Government has had a good record in astronomy, and there are certain aspects of astronomy that are obviously Government responsibilities, but astronomy, in a broad way and as a research field in science, is probably not a Government responsibility. Here I am expressing personal opinions.

Also, when you start to recommend a thing like a big telescope which, in the field of astronomy, becomes a major expenditure in that field for many years for Canada, you have to look at the whole of the scientific community.

At this point I had better put in my disclaimer as Chancellor of the University of Toronto at the time this telescope was proposed, when something like 90 per cent of the graduates in astronomy were at the University of Toronto. Here was a proposal put up—by government officials—without really thinking that they were going to disrupt the academic society in astronomy in Canada by moving the astronomy out to British Columbia.

Senator Grosart: Who made the decision to go ahead with it?

Dr. Solandt: The decision was made by the federal Government—I guess, by the cabinet, finally.

Senator Hays: On whose recommendation?

Dr. Solandt: By the Department of Energy, Mines and Resources—it was called by another name then, the Department of Mines and Technical Surveys. The point was that this was not a recommendation from the point of view of the national interest: this was a recommendation from the point of view of a departmental interest. The department had discussed this through this National Advisory Committee with the university. I have talked to several of the university people afterwards and they did not realize their role. As they understood it, the Government members of the committee were saying "we are going to be able to build a good new telescope, would you not support us in getting it?" It never occurred to them that they might have got the telescope; they thought it was agreed that their friends were getting a new telescope and would let them use it some of the time. So this was a departmental recommendation—it was a sensible, well thought out recommendation—but it was put forward from a departmental rather than a national point of view, by the committee.

The Chairman: And the University of Toronto was caught sleeping again?

Dr. Solandt: The University of Toronto was represented on the committee by the professor of Astronomy so it was not a question that they did not know about it. The National Research Council formally approved this at a meeting. I have talked to some of them, but they said they approved of it as a scientific venture, no one thought about its national implications.

I say this not to be critical of the people involved but to indicate the answer to your question, that if the Science Council had done a good job of looking at the national interest in scientific matters, we would have made a report which would have made it quite clear what kind of projects would fit into this policy, if the Government felt they could afford them. We were not involved in the details. If this had been done carefully, then Senator MacKenzie's other criticism would not have happened. If this had been widely discussed and if it were felt that this were a project that would have the unanimous support of the scientific community, and that the need of it was widely understood by the people and by the political leaders, then I do not think it would have become cancelled.

Senator Grosart: How do you get the unanimous support of the scientific community for any project?

Dr. Solandt: I think that in most cases it is by long discussion. I know that some people may be cynical about this, but I think one can come a lot closer to getting unanimous support than we had either in the case of the telescope of the ING.

Senator Grosart: Were the deans of the university not given an opportunity, when something like this was being done, to make their views known earlier?

Dr. Solandt: Not the deans, but the universities were interested in those activities. One

thing I felt very strongly about is, I have forgotten whether it was the deans who may have done this—but many people said "let us not do ING, because there are so many other things we can do." If you say to them, for instance, that you will spend $7½ million and work up to $20 to $25 million in two or three years, what project have you got that is of equal importance, equally well understood scientifically, that you can start to spend that money now—there is not one, there just is not one.

You see, what has been happening with the postponement of ING is that we are postponing something that we could do now, that is timely and important, in favour of something that conceivably is more important but cannot be started for several years. The argument put forward, in the original Science Council report, was that it looked as if ING were going to pre-empt a lot of our money for research for the future, but if certain research expenditures grew, even at the rate required to reach 2 per cent of GNP level in a few years, then there would be lots of money available for the other things we wanted to do.

Senator Grosart: Would you suggest, then, that the Government expenditure on science R and D should be really limited, that major Government expenditure should be limited to the priority set forth in your Report No. 4? If astronomy is not there, are you satisfied that the Government should not involve itself in a major expenditure in astronomy?

Dr. Solandt: No, we have said quite clearly that we are here recommending changes in the program, designed to change the direction of our total effort; but we are not recommending stopping work on anything that is not specifically listed So far as astronomy goes, I certainly have the intention that, when we have time, the Science Council would look at Canada's interest in astronomy from a national point of view.

Senator MacKenzie: That is what I am getting at, Mr. Chairman, that is what I want—that study made by the Science Council.

Dr. Solandt: I do not think we should start out by saying: "Is the Queen Elizabeth II a good thing or not?"

Senator MacKenzie: No, no. Start right from the beginning.

The Chairman: You were saying earlier about ING—and I think Dr. Gaudry confirmed this—that if you were to report today you would deal with the problem in a different way. In what different way would you deal with it now?

Dr. Solandt: I do not think I would look at it very much differently. I think our interests would be in its potential importance to the nuclear power program, and that would be weighed a little more heavily. The way we look at it now, and the way many people have for a long time, is that the thing that really matters in Canada today is that we push forward with the nuclear power program. I think very few Canadians realize how successful this has been, what a really spectacularly good progress we have made. The Canadian heavy water moderated natural uranium fueled reactors are right at the top line of competitors for nuclear power throughout the world. I think there is still a very good chance that they will prove to be the most successful—not forever but say for the next ten or fifteen years. This is something which we should reinforce, when we have these successes, that we should ensure that they are not starved or resources to do the development to keep in the forefront. I would say that is the first priority, and that ING would only be supported if it were important support for the nuclear power program.

Since we reviewed ING, I think that the possibility of its being an important support has probably increased. You would have to ask more expert people than I for an opinion, but that would be my impression. Therefore, I would have said that if we have the money we still should do ING, but if we are short of money I do not think there is any argument that the things that are closer to the nuclear power program should have priority.

Senator Grosart: You said you briefly looked at the alternatives in your report. Is there any significance in the qualifications? The alternatives proposed by AECL? In your report on ING you said we looked at these alternatives. As I understand it, you are speaking of the alternatives.

Dr. Solandt: No, no. The alternatives referred to there were alternative research projects, not alternative sources of expenditure on development.

Senator Thompson: I would like to pursue this because I feel it is important that we

should try to understand more completely the method by which decisions are formulated concerning the development of scientific projects. I would like to say that it is the mechanics of assessment and the process of making decisions that I would really like to have clarified. I am not talking about the pros and cons of either ING or the telescope; it is the mechanics by which you get the decisions.

Over the weekend our secretariat gave us an enormous amount of homework. Perhaps I should say at this point that I am in a sense ashamed that it was only this weekend that I read the reports and I understand that some of the people who prepared them are present—I will admit I do not know the difference between indirect and direct wiring, but the lucidity and clarity to which this is expressed to me—I was very absorbed in each of these reports and I congratulate them on being able to express to laymen the points of view they wanted to bring forth.

I also read a technical assessment seminar which Dr. Mackenzie has already referred to and which was carried out by the 90th Congress. I would like to take a couple of very strong assumptions they brought forward. They first suggested that Congressmen—I put other public servants, public representatives in this category, that we really are not into the 20th century in being able to understand scientific jargon or knowledge. On the other hand, I would like to express that from prehistoric times man has always had to make decisions about technological tools. When early man discovered the stick, he had to know how to beat his wife with it or slay his enemy with it.

The Chairman: Is that not the same thing?

Senator Thompson: The other assumption is—and the seminar emphasized this—that scientists are dedicated men who give their lives to pursuing knowledge about a certain narrow subject, and being human they are inclined to be biased towards that particular discipline. Now, having said that, I would like to quote from the *Technology Assessment Seminar,* page 154, where it is stated that some of the difficulties in submitting a technological assessment by any public body are:

> . . . (1) the skills and professional biases of the personnel involved,

It is natural when a scientist has spent a great deal of work on it. It further states:

> . . . (2) failure to give adequate representation to all relevant viewpoints and interests,

by a scientific community presenting a case. Then,

> . . . (3) overemphasis on short-term economic criteria relative to broader and longer range social criteria, especially in the private sector, (4) an inadequate information base, with no feedback toward improving the data-collection system, (5) lack of a mechanism for identifying the most important problems at any one time, taking into account that the political process is inherently limited in the number of issues which can command political attention at any one time.

The seminar then made suggestions about the kind of machinery that could be set up to make a technical assessment and if I could quote from that—it is on page 115. Having just presented these principles which the seminar enunciated with respect to examining any proposal, perhaps I could relate them to ING and ask if this procedure was followed in connection with ING.

The first thing is that there should be a technical, rigorous analysis of the process. There is no question at all of its utility, desirability and so forth. We want to find out just what the technical situation is, spelled out exactly and in as much detail as possible. The second point is that whoever presents this technical description, if it is to the Assessment Board or if it is the Assessment Board itself, it should not at one and the same time be the group to make the assessment in the sense of making the judgment about utility or inutility, development or cancellation.

One of the problems we have in Canada is that we have so few people with a prominence in science that perhaps we do have a situation on the Science Council such that people who are making proposals, even on a major project such as ING, are also part of the Science Council passing judgment on whether this should be forwarded to the cabinet.

I think you pointed out that you see this as a worry, but because of the lack of top people there is not much we can do about it.

Now, the second thing it should do is to separately prepare a list of what the advantages are—perhaps again with reference to ING—and what benefits would accrue, what things might be perceived to be resultant which people would be happy with having. Then just take the opposite: what kind of things might result which would be detrimen-

tal and with which people might not be so happy.

They suggested that there should be a confrontation panel. In other words, that with the Science Council you should have the proponents of ING and you should also have the people who feel very strongly that it should not go ahead.

I, as a layman, pick up things about ING after the event. It is always easy, of course, to hear criticisms after the event.

I wonder whether it would have been useful to you if this kind of thing had been presented to you as a contrary argument to ING. The fact that in the United States, for example, as I understand it, in 1950 MTA, the Material Testing Accelerator, was conceived and $50 million was spent on it. It was something similar to ING. I am a layman on this, but I just throw this out for your comments on it. They had gone ahead on this MTA in the United States and there had been a statement in a magazine by Dr. Rosen in 1966 just surveying the whole approach toward this MTA. He was showing what was being done at Oak Ridge. They had also had an American patent for the commercial use of the isotopes which would mean that this might limit the economic advantage that Canada would get from having developed ING.

I think it was the Department of Transport that came out with a study suggesting that this was not really a sound economic project to go into. However, on the other hand, I am sure that those kinds of contrary suggestions were considered by the Science Council. But I would suggest, Mr. Chairman, that one of the things the seminar bring forward here is that this confrontation panel should not only take place before a Science Council which is the assessment board but also should take place before an existing political body. And at this point we have not any, except the Senate Committee itself. In the United States, however, they have a congressional committee and they argue very strongly, apparently, in this assessment seminar in favour of using Congress to help them make a decision on the pros and cons of these matters, because I would think that if you had had either a parliamentary committee or a Senate committee in which you could have given us the pros and cons of ING and then assured us from your highly professional background with the Science Council that you felt we should go ahead with this because of national purpose and so on we would be able to support you in the political arena where the decision obviously was made to curtail it. I would think then there would have been a far greater fight to prevent curtailment of ING or the telescope or any other project that might be involved. What we need is a body of politicians doing homework and reading these excellent booklets that you have prepared and becoming familiar with the jargon so that they could take part in the decision making even at a low level and so that as a background to the executive body there would be in Parliament and in the Senate another group taking part in this dialogue. Now, Dr. Solandt, in making this statement I have also asked some questions, and generally I would appreciate your comments on it.

Dr. Solandt: I think you pointed out a very important factor in the decision making process. As far as ING goes, all the early stages of this were handled, I think, extremely well in the way you have outlined. That is the technical feasibility and excellence of the project which was reviewed very carefully in a series of papers put out by Chalk River and discussed at national, and even more important, international scientific meetings where it was compared by critical scientists with other possibilities. There is no doubt that out of this discussion ING came as a very interesting, exciting possibility and one that scientists in this particular field all over the world hoped would go ahead. That is one of the first things—we have to make sure it is good at that level. Then the Science Council committee that looked into this was carefully selected so as to have on it no one who was deeply involved with ING but also so as to have as much expert knowledge available as we could find. As you say, in Canada this is sometimes difficult because all the real experts are involved. In this case, however, we imported a few experts from the United States and I think we had one from England as well. We wanted to have people knowledgeable in the field but who didn't have a vested interested in seing ING go ahead. On the basis of this we considered it to be a good thing.

As you pointed out, we don't have a mechanism for dealing with the next stage which is the difficulty of deciding whether ING is more important than, say, medicare or some other quite different type of expenditure, and this kind of decision can of course be made only at the political level. You cannot expect any group of officials to get togeth-

er and decide between the expenditure of ING and some quite unrelated and not comparable expenditure. Yet somebody has to make these expenditures and these assessments and that is what governments have to do. It is very difficult and it is very unscientific also. You can use a certain amount of science in getting your facts well organized and marshalled, but in the final analysis somebody has to make an estimate of what is the best thing to do.

Senator Thompson: Do you mind if I interrupt here, Dr. Solandt? In going through this seminar report there was quite a bit of discussion on informing the public so that they fould participate in the decision-making.

They talk of, for example, the *Science Citizen* a magazine which apparently goes out to editors across the United States and so on. It seems, at least from the seminar, that there is a much greater effort to get this across to the public before final decisions are made.

Dr. Solandt: There is. We have a magazine "Science Forum" now in Canada which is doing quite a job in this field, which was set up specifically with this in mind, so we are very conscious of the problem. We are delighted you people are interested in trying to find a solution. The U.S. congressional committee system is really quite a good one. As you know, it again has two levels. There are specialist committees which do the special pleading for their particular field of interest, and who in turn plead to the general committees which assign priorities for funds. We have no comparable mechanism. Of the specialist committees in the U.S. one of the most familiar is Mr. Daddario's Subcommittee on Science and Astronautics. These specialist committees are quite well informed because they devote a lot of time and learning to the subject. They listen to the scientific community on the one side and talk to the appropriations committees on the other side, so you have them as a link.

Senator Bourget: Do they have technical advisers?

Dr. Solandt: They have quite large staffs of their own and they work very closely with the scientific community and pull in technical advisers. That committee works particularly closely with the National Academy of Sciences.

Senator Bourget: If they were working alone it would be difficult. In this committee it would be very difficult for any of us to understand the technical implications of it. That is the reason I am asking if that kind of committee should have some technical advisers to enable it to understand the implications exactly.

Dr. Solandt: They behave very much as your committee does. They have a small expert staff of their own which helps them, and in addition they call in outside advisers who are specialists in whatever field they are at that moment discussing.

Senator Thompson: May I just finish my question?

The Chairman: I am sorry, Senator Thompson, but I know that Dr. Solandt has an appointment at one o'clock, and he is a very important man in the present circumstances.

Senator Thompson: I realize that.

Dr. Solandt: It is not that I am important, but my commitment is.

Senator Thompson: I can be very brief. I notice that one of the recommendations of the British Atomic Energy Authority has been that there should be a separate assessment for evaluating all the proposed programs of the British Atomic Energy Authority. My impression is that, although the British are quite advanced in the whole field of nuclear development, they are still making a hard assessment of it. You speak of our Canadian effort enthusiastically and in glowing terms. Do you think we should be having an assessment of it ourselves? Would you put it near the top of your priorities? Do you think there should be a harder look at this?

Dr. Solandt: At which?

Senator Thompson: At our whole approach towards encouraging such things as ING, putting it into a nuclear development program. As I understand, you feel it should be one of the things we should be encouraging, or that the Science Council should be encouraging.

Senator Grosart: Mr. Chairman, it will be a long answer, and I suggest we leave it until 8 o'clock.

The committee adjourned.

EVENING SITTING

(Second Session)

At 8.00 p.m. the meeting was resumed.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, I call the meeting to order.

I would like to remind members of the committee that, before we go into greater detail in the report itself, we should endeavour in this first stage of our discussion period to concentrate as much as possible on the role of the Science Council in the process of science policy formulation and other related questions as to the structure and composition of the Council.

I think this morning that we really interrupted Senator Thompson and we might come back to this question.

Senator Thompson: Mr. Chairman, I wonder if I could continue with the question I put this morning? Dr. Solandt, I am sure I speak for the chairman and the committee when I say we appreciate so much both of you coming back again to answer questions and to give us information.

My question this morning had to do with the enthusiasm and emphasis which is being expressed concerning Canada's nuclear power program. In this connection I would like to quote from Report No. 4 of the Science Council of Canada.

At page 35 it states:

> Canada's nuclear power program is one existing major program which has been particularly successful and which has secured for Canada a prominent position in the world market in this highly competitive field.

There are similar quotations on page 47, and elsewhere in the report.

Again my question is in connection with assessment, and I raise this for the reason that other countries, as I understand it, are looking at this whole area of nuclear power. For example, earlier this year the Select Committee of the British House of Commons published its findings in a large report. One of the recommendations of that Select Committee was that a separate assessment board should be set up to assess all programs of the British Atomic Energy Authority.

I wonder if at this point you think that we should be doing an assessment of our nuclear power? Based on your intimate knowledge, do you think we are in a position to be thoroughly enthusiastic about the opportunity nuclear power will give Canada's economic development as well as opportunities in the world market?

Dr. Solandt: I think the first answer to that is that we have a continuing assessment contained in the form of the Board of Directors at Atomic Energy of Canada Limited, who are a very distinguished group, partly scientists and engineers and partly people in the power industry, who do meet, I am not sure whether it is monthly or every two months, to review the rpograms of Atomic Energy of Canada.

So that I think is a very effective first review mechanism. I do not know what sort of review mechanism you would have beyond that, unless a committee such as this that would listen to the arguments to decide whether they are convincing or not, because there is no group in Canada better able to review these projects than the people in AECL, plus their Board of Directors.

Senator Thompson: Again I come back to the idea of a group, a political group, which should be made aware of various potentials. I have in the back of my mind that it would act as a confrontation sort of panel with the Science Council, to consider these things that you have said are thrown at you to make decisions on.

This morning I gathered that you felt it would be useful to you if our Science Committee were to evolve into something similar to a Congressional Committee, but it seems to me that the aspect of nuclear power and enthusiasm for it is made by the people who are working in it. As I mentioned at the start of my remarks, these people will promote this very deeply, but they are biased in this.

Dr. Solandt: Yes, but I would just like to comment that—and I am sure you will agree—this is true of everyone. It is not peculiar to scientists.

Senator Thompson: No, no, I agree.

Dr. Solandt: There is often a feeling that scientists should be so pure that they do not promote their work while everyone else is busy promoting his.

I disagree with this. I think that you reach a good decision when you have advocates of different points of view, good advocates, well informed and believable and then you weigh the pros and cons. You are in trouble if you have a good advocate for one point of view and a poor advocate for another point of view, which may in fact be a better point of view but one that is poorly put.

So I am in favour of having scientists who are good advocates, who will put their proposals lucidly and clearly and set out the advantages and the disadvantages and, as I see it, to follow your line of reasoning, it seems to me that you want first of all a committee of some kind which is made up of knowledgeable experts but who are not dedicated go the particular project and in this case the Board of AECL is quite satisfactory for that purpose. But then you are suggesting and I would agree, that at the next level you want a group of people who are politically oriented and who have a broader interest in a lot of aspects of national policy, but who are well enough informed to understand broadly what the scientist is talking about, because this is when you begin to weigh the scientific program against other programs that may be quite different, in which the scientist will have nothing, or very little, to contribute in the judgment.

Senator Thompson: Dr. Solandt, my last question still relates to the effect of bias in scientists, which is in all human beings if they have a sense of dedication to their work—naturally they are going to be for it, otherwise they would not be spending their life and their talent in pursuing it. My question is with respect to the structure of the Science Council in relation to government. I would just like to get that straight again.

As I understood it, previously it could be that the Secretariat would do some sort of a report on a study for the Science Council. The Science Council would then refer this to the appropriate Minister or to the Prime Minister for the government's approval. The government in turn would then go to the Secretariat to ask their advice on this study. At this point in the past, the Secretariat, who wore a different hat, would not say: "Well, we actually initiated the study", but they would give their advice on it and then the government might approve it.

Am I inaccurate in that statement, that that did take place previously?

Dr. Solandt: I hope so. It has always been a worry. The Secretariat's relationship to the Council has merely been one of supplying staff; but a report like this, which is labeled a science Secretariat study, was really done by the staff of the Secretariat working for the Science Council. This report was referred not by the Secretariat to the Council but by its own staff to the Council, and in future these reports will be labeled Science Council Reports.

There is of course a danger that when the Science Council has formulated its advice and passed it to the Prime Minister that he will pass it back to the Secretariat as his science staff to tell him what to do. We hope that we are always close enough to the Secretariat that he will get the same advice there as he did from us.

He of course can pass a report to any number of other agencies for advice and I suppose might well do so if he suspected our advice as being biased, but I visualize the Science Council's job as being to try to give to the Prime Minister and the government a consensus of opinion of the scientific community, not just the views of the members of the Council.

We do make a real effort to try to enlist on Committees, and invite to submit reports to Committees or to put in briefs, all the elements of the scientific community that have an interest a particular subject.

So what we are trying to do is to act as the spokesman for the scientific community rather than just to present our own opinions.

Senator Thompson: I think, Dr. Gaudry, during the recess, you mentioned something to me which corresponds with Dr. Solandt's view. I wonder if you want to say anything to the Committee on this?

Dr. Gaudry: Well, I was just going to say that we hope the present system whereby the Science Council and the Secretariat are separated will work. I think it has to work provided that the Secretariat staff does not become so large that it acts as a Science Council all by itself, because if in a number of instances the Science Council's recommendations were not found to be acceptable by the government or if, to put it differently, there were other advisors who advised differently, I think that in no time at all the Science Council would cease to exist.

The Science Council is there to advise; the people who are members give their time willingly to that, but I think that the advice that they give, if not fairly often accepted, would mean that they have no real purpose. I hope that this will never happen.

Senator Bourget: So it does mean then that this is the only body, the sole body who will make recommendations to the government, through the Minister, through the Prime Minister or somebody else, that you will be the only body who will make recommendations and the Science Secretariat will not interfere; you will be a kind of Supreme Court.

Dr. Gaudry: Well, not quite. I think that we should be the only people to speak on behalf of the scientific community of the country; the government can do what they want for their reasons, but I don't think that the government should, after having received the advice of the scientific community, ask for the advice of another scientific group.

Senator Bourget: That is it; that is what I wanted to make clear in my own mind, that you will be the only body that will make recommendations; if they are refused or accepted, that is all right, but you will be the only body to make recommendations?

Dr. Gaudry: I would hope so, yes.

Senator Bourget: Now, if it is the case then that you report and make a recommendation to the Minister or the President of Treasury Board, who would advise the President of Treasury Board, who is not a scientist, how can he appreciate without having the scientific knowledge?

Do you think that he should be advised, have an assistant like the President of the United States has a Science Assistant?

Dr. Gaudry: Well, I think there must be found a mechanism by which the recommendations of the Science Council reach the Cabinet level and are properly explained and expressed and are well defended there.

We think that the Prime Minister cannot be the man who can spend enough time to study in detail the recommendations of the Science Council; therefore I think that we must go through some mechanism.

I do not know, this is just guess work, it could be say a Minister without Portfolio whose job it would be to look after science, for instance, in the Cabinet; I don't know, this is just one of many possibilities, but I think that we have to find a mechanism by which we have access to the decision-making powers of the government.

Senator Bourget: Do you think that would be a good recommendation for the Committee to make, that a Minister without Portfolio be appointed?

Dr. Gaudry: I am not making this as a recommendation of the Science Council, no, but I think more and more personally that this could perhaps be a good solution, but I am not familiar enough with all the mechanisms of government decision-making to be certain.

The Chairman: He is not a privy councillor.

Dr. Solandt: I might just add a word on how the Americans have solved this problem: You said that the President has a science advisor, Dr. Hornig. They also have an Office of Science and Technology, which corresponds very closely to the Science Secretariat, although it is in a little different position. The head of that is Dr. Hornig. They have a President's Science Advisory Committee, which is very much like the Science Council. The Chairman of that is Dr. Hornig. They have the Federal Council for Science and Technology, which corresponds to our Advisory Panel on Scientific and Industrial Research. It is the official body corresponding to the Privy Council Committee. The Chairman of that is Dr. Hornig.

So they have solved this problem of conflict of advice by having only one person doing all these jobs.

The Chairman: In a very different political structure, as we saw last night.

Senator Bourget: Mr. Chairman, could I ask one more question?

The Chairman: Yes.

Senator Bourget: It has to do with permanent members of the Science Council. I think we discussed that this morning in answering a question. Do you think it would be advisable that the Science Council should have permanent members? Personally I do not know how many times you meet, but so as to understand more of the problems should not you have on that Board some members who would be permanent?

The Chairman: You mean full-time, not permanent?

Senator Bourget: Full time, yes. That is what I mean.

The Chairman: Not senators.

Senator Bourget: They would be Civil Service employees and permanent.

Dr. Solandt: I think we discussed the view on that this morning, that I think there is no doubt that it would be a good idea to have some full-time members, if they were not permanent. The problem is really to be sure that this can be achieved.

The Chairman: It can be achieved very easily I think by providing in the Act that the term of office will be limited, let us say, to six years, and will not be renewable.

Senator MacKenzie: What do you do with the poor fellow after the six years.

The Chairman: He will get a hundred thousand dollars-a-year job to advise industry.

Senator Grosart: Mr. Chairman, I hope I will have an opportunity to ask some questions later on the report, but in the meantime I would like to come back to the question raised by both Senator Thompson and Senator Bourget, about the mechanism.

I am not satisfied that we are anywhere close to having a workable mechanism. I notice that Mr. Drury in a speech he made a short time ago said that mechanisms must be found to carry out our national policies and programs, and that new institutions may be required to prosecute major initiatives in science and technology.

Dr. Solandt, I understood in answer to a previous question tonight that you said that the Science Council would be the only entity advising in the long-term area. Leaving aside for the moment the short-term advice, is this wise? Is not the American system better, where they have two really independent streams of advice coming in, one through the President's Advisory Council and one through the National Academy of Sciences.

I support this by quoting from an article by John Lear, whom you may know, one of the outstanding science writers in the United States, and Science Editor of *Saturday Review*, who describes the function of the National Academy of Sciences as a congressionally chartered scientific advisor to government.

Then, of course, we have the Advisory Council. The witness we had from the United States who gave us the evidence on the American system, Dr. Killian, made quite a point of the importance of these two independent sources of advice going to the government, one to the President.

Is not this a sound idea?

Dr. Solandt: Might I speak on that, because I think there was a misunderstanding of what Dr. Gaudry said; at least, unless I misunderstand it I disagree with it but I think what he was saying was that within the immediate—

The Chairman: Cabinet solidarity!

Dr. Solandt: —group of people advising the Prime Minister directly as their job so to speak, there would only be the Science Council, but that the Prime Minister should get advice on science policy, as he does on every other aspect of policy, from a wide variety of different advisors. There is a great deal to be said for encouraging the independent professional societies and other groups of this kind to give policy advice both to the government and to the Science Council. We do want to encourage the kind of widespread discussion of science policy that goes on in the States.

Now, there has also been discussion in Canada that we might try to develop the Royal Society into a body something like the National Academy of Sciences. This policy-forming function, or policy-advisory function of the National Academy of Sciences is quite new. I should not put it that way: The National Academy of Sciences was set up by Abraham Lincoln, I think it was, to advise the government on science policy at a time when there was practically no science in government and no other scientific advisory mechanism. Over the years it dropped right out of the field and it only got into it again under Dr. Bronk, who was the President before Seitz, in the last 20 or 15 years.

It has proven to be very successful, because it has given advice from a very detached and somewhat academic point of view, which has been quite an important input to the President's Science Advisory Committee but I do not think the two groups regard themselves as competitive. They are complementary, and I do not think they have ever run head on into each other in advising the government in opposite directions.

Senator Grosart: No, I did not mean to suggest that. I perhaps used the word in the

sense that their data gathering and analysis and assessment and policy judgments are separate channels coming to the President in that case. It seems to me that there is an advantage in this, particularly if you take some of these particular cases taking the Arrow or the ING or the telescope in British Columbia, that one group seems to have left out some of the people who would like to have been heard and for some reason or other were not heard.

The Chairman: Before you answer it, at what level would you like this kind of parallel advice to be given? This morning I was asking some questions about this parallel exercise between the Science Council and what will be left of the Science Secretariat in the Privy Council office. Then we have two parallel operations, two bodies really advising the minister in fact on similar problems. If we were in our own structure of government to do that for science in the Privy Council office, why not do it also for agriculture, foreign affairs, trade and commerce, so as to try to have a kind of shadow government in the Privy Council office?

Senator Grosart: Now, Mr. Chairman, you frighten me by becoming the questioner and expecting me to answer, because I have not the faintest notion what the answer is. The question I am asking is—at what level?

The Chairman: I wanted you to be more precise in your question.

Senator Grosart: Well, I do not know how much more precise it can be than to say: is it a good idea to have these two on the American pattern? If that is not precise enough I will abandon the question.

Dr. Gaudry: I would like to try to answer that question by saying this: Personally I am very much in favour of having some sort of Canadian Academy of Science. I think that one of the problems in a country the size of ours is really to try to get fairly rapidly and completely the consensus of the Canadian scientific community and any mechanism that would help us do that would be very useful.

I said that I thought that we in the Science Council were trying to represent the scientific community, but we cannot ask all the scientists before making a recommendation, but the more information we get from the scientific community the better.

Either a Canadian Academy of Science, or some similar body would be very useful to bring to bear on Canada the opinion of a much larger number of scientists, but when I felt that there should not be two bodies advising the government I was rather speaking of a very small body working in a vacuum separate from the scientific community. The American system, I think, would be completely compatible with what we have in mind.

Senator Grosart: I am glad to hear you say that, because Mr. Drury has suggested this polarism of concept; he had asked in this speech and in other speeches should we have a ministry of technology, or a ministry of science, or whatever you like to call it, or—and this is his phrase—should we prefer this on the European model, or the highly diffused but well co-ordinated pattern of the United States government?

I presume this is what you were speaking of, Dr. Solandt?

Dr. Solandt: Yes, but...

Senator Grosart: He is prepared to call it highly diffused but well co-ordinated. What I am really asking is should we go to the British system or to the European system or to the American system, or should we come up with one of our own, because to me the vital question before this Committee vis-a-vis the Science Council is the mechanism..

Dr. Solandt: I think that we should develop our own. I think the ideal one for us, is more likely to follow along the American lines than along the British or French, partly because we tend to do business more in that way.

I think that if we develop a mechanism such as you have suggested with not only a government organized body like the Science Council, but other sources of advice that are less closely organized, as the National Academy is, this will begin to build up that side of the mechanism.

I am much more concerned with the Central connection of the advisory mechanism, and this is a big difference between ours and the American one, because Dr. Hornig who is at the centre of their mechanism is a direct personal advisor to the President; he is part of the President's staff. The Office of Science and Technology is parallel in organization to the Bureau of the Budget and in fact is housed right next door to it. So that the advice of that group is coupled very closely and intimately to the decision mechanism of the government.

The Chairman: The American system and ours are completely different, but in our own terms would not you agree that Dr. Hornig is more or less in the position of at least a Minister without Portfolio in our own system?

Dr. Solandt: Yes.

The Chairman: Because he seems to be a very powerful man with a lot of responsibilities as you have just described him, to be really the centre in so far as getting information is concerned and giving advice.

Dr. Solandt: Well, as you know, his position is more like that of a Cabinet Minister. He is appointed by the President with the advice and consent of the Senate.

The Chairman: I understand he is going in January.

Dr. Solandt: Yes, but he has been there five years, which is a considerably long time for that. So you cannot force the parallel between these two too closely.

If you look at the French experience, for instance, they started by having a delegate general for science who reported to the Prime Minister. Then he gradually began to have a major responsibility putting together the research budgets, the science budgets of all the different departments into an envelope, as they called it, for science. Then they found that this did not work very well, because the Prime Minister did not have time and they appointed a Minister for Science, who really just acts between the delegate general and the Prime Minister, but to my mind they have confused the issue by making the Minister for Science responsible for atomic energy and space, so he has now got an operating department and is no longer an objective policy advisor and I am sure is suspect by all the other departments.

So they, after starting with a logical organization as one would expect of the French, have become almost as illogical as we are.

The British really I think are in organizational chaos in their science; I could give you my picture of it, which may not be accurate, but I do not think we should do anything other than learn by their mistakes, to try to avoid most of the things they have done in the last few years.

The Chairman: What about Germany?

Dr. Solandt: I am not really familiar with their system.

The Chairman: Because theirs is the closest or most analogous situation to ours in the sense that they have a federal system.

Dr. Solandt: Yes. I do not know how they do it.

Senator Grosart: Mr. Chairman, this brings me back to my question of this morning, which I do not think Dr. Solandt answered. It was this: If the basic concept of the Science Council advises long-term projections, who will give the Cabinet, the Prime Minister, the Privy Council, short-term advice?

The example I would take again is ING where they have the advice of the Science Council and the advice of the Secretariat, both appraising it and giving it high priority in terms of national goals, as your own report did.

The Cabinet decides we are going to cut it down, we are going to stop it. Now, whom do we turn to at this point? Where do they get the advice on which they decide not to take the advice of the Science Council and the Secretariat?

I am not being critical. I am interested just in the mechanism for the future. How can a group of laymen say in spite of the advice of the Science Council, in spite of the advice of the Secretariat, admitting we have some contrary advice from deans of engineering, backing up an associate dean of engineering and then some associates of the associates; we want to dissociate ourselves from the associates. I can understand the confusion in the Cabinet when they are faced with that kind of situation.

But looking to the future, you spoke of the connecting link, this point of input on short-term decisions, which are really the business of politics. The politicians must make the short term decisions. We can rely on many people for the long-term projections; this unfortunate job is to say what do we do today. Who is going to advise the government in the future if you are going to restrict yourself to long-term advice?

Dr. Solandt: Well, I had attempted to convey the idea that we were not going to limit ouselves to long-term advice in the sense of advice that would only affect events a long time in the future, but rather strategic advice in the sense of the big outlines of policy and that if these were adequately done then many of the technical decisions, the smaller ones, could easily be taken within this framework.

I would visualize that in future as we get a good framework built up the Science Council will be more frequently called on by the government for specific advice on major projects, even though they may be fairly short term if they are big and important, and we would then be able to advise them quite well on them because of our background of knowledge of the broad structure that we had envisaged for the policy of the nation.

For instance, I discussed the telescope this morning and I think ING is the same kind of thing, that once we have policies clearly envisaged in these areas and particularly as we begin to get some picture of what rate of expansion for science expenditure the government is willing to foresee, then we would be much more receptive to being asked for advice on short term objectives.

Our objection to ING as it was originally given to us was that we were in a sense asked to advise on a detail, but a very big detail, in a picture that we had not yet begun to paint, we could not even see.

Senator Grosart: But this morning I think you said that you felt the need for ING was even more important now than when you made your report. So to that extent your problem was not that you did not make a good analysis.

Dr. Solandt: Oh, no; I think we were remarkably lucky in our analysis, or maybe I should say that our advisors who worked on the report were remarkably skillful. I still think it is good, and you asked where the government got further scientific advice on it. I do not think they took further scientific advice. I think they just decided that they did not have the money for ING. I do not think anybody said ING was a poor project.

Senator Grosart: Well, admitting that the Government, quite rightly, has to cut somewhere, my question is: Why did they pick this particular $7.5 million which we are dealing with in this year's budget, which was supported by the tremendous recommendation it was, instead of picking some place to cut that no one had recommended, or no similar body to the Science Council and the Science Secretariat had recommended?

This is the problem. The Prime Minister's statement did not restrict the components of that judgment to the financial situation. He mentioned the fact that there were other scientists objecting and when I put the question to the witnesses from the AECL if my construction of the steps leading up to it were correct, the answer was yes, and I again spoke of the deans and the letters to the papers and so on which as far as we, as far as any layman knows, is the only other component that went into it apart from a financial one other than the advice of the Council and the Secretariat.

Again, I am not being critical. I am only concerned what the government in power—

Senator Mackenzie: Mr. Chairman, could I check with Senator Grosart on this seven and a half million? Is it not a fact that this was a preliminary amount. The total project was—

Senator Grosart: Was $155 million.

Senator Mackenzie: The total project was going to lead the government to expenditure on science within a fairly limited period of time for $150 million plus. That is different from seven and a half million.

The Chairman: I think the figure which was mentioned was on the average, more or less, about $20 million including capital costs and operations—for an indefinite period.

Senator Grosart: Yes, but Senator MacKenzie, my reason for saying seven and a half million is that the government did not say—

The Chairman: It was a conservative estimate.

Senator Grosart: But even so, the government did not say, "We are washing out the whole $155 million". In fact, the inference I got from the statement was that it might be reinstated at some future time, so they were dealing only with the immediate question at that time. Again I say I am concerned about this connecting link. Where at this point does the government, any government, turn for advice?

May I just add this, and it will finish my part of the questioning: Senator Gordon Allott, whom you may know, is the ranking member of the Senate Appropriations Subcommittee which is charged with funding the National Science Foundation and the National Aeronautics and Space Administration. He is also a member of the Senate Defence Appropriations Committee. He is a man of some experience, and he says this:

> I ask leave to observe that the admitted lack of expertise on the part of the majority of members of Congress in areas

> relating to scientific achievement is regrettably matched only by the lack of appreciation on the part of many research scientists, engineers and technical managers of congressional processes and problems.
>
> On occasions so rare that I can scarcely recall them have I ever received comments from the scientific community relative to how its operation might possibly be improved, where the waste is, where the duplication is, where the inefficiency lies, what the real difficulties and problems are.

In other words, he says the decision maker does not know enough and the scientific community is not doing its job in educating him. Is that our situation?

Dr. Solandt: I certainly feel that the communication between the scientific community and the whole legislative mechanism in Canada has in the past been very poor, very desultory and unsystematic. One of the real objectives of the Science Council has been to try to improve this, and I think that there has been a marked improvement.

If you look at the amount that is published in the newspapers and in the special journals like the *Financial Post* and *Financial Times* and our new science journal, the *Science Forum,* I am sure that the amount of discussion about science and science policy that is published in Canada in a month now is ten times what it was even three years ago.

Senator Grosart: I agree.

Dr. Solandt: And I believe that the existence of this Committee has done a lot to help in this communication. I certainly feel that the scientific community deserves a large share of the blame in this. They have been quite apathetic in trying to communicate with others, because they have not felt it was necessary and it is clear that it is becoming necessary.

I have said this elsewhere and I would repeat now that I think, in the case of both ING and the telescope, the cancellation was to a large extent due to this failure first of all to communicate within the scientific community to get a consensus of what needed to be done, then to communicate the consensus intelligently to Parliament and to the public.

It seems to me that if these scientific projects are well conceived, thoroughly understood—their objectives from the national point of view understood—then they will get very high priority as objects of expenditure but, of course, they can never be sure of always being funded regardless of what the other claims are, because they are in competition with alternatives.

Senator Grosart: Thank you very much, Dr. Solandt. The longer I listen to you the more optimistic I get about the future.

The Chairman: Senator Hays?

Senator Hays: Doctor, could you for the Committee take a program that you were very interested in that you felt that we should be doing someithng with and just give us an example and follow it through from the time you first learned about it until it was completed—a program, and how you handled it?

Dr. Solandt: As Chairman of the Science Council?

Senator Hays: Yes.

Dr. Solandt: There is no such a thing; we have not been going long enough. We have not had any recommendation accepted and carried through to completion.

Senator Hays: How do you make your recommendations? How do you learn about a program in the first place, and follow it right through? How do you handle it? How often do you meet, and who makes the presentation and all this sort of thing?

Dr. Solandt: First of all, on the straight mechanics we meet six times a year and we try to deal only, as far as major discussions go, with papers that have been prepared and circulated beforehand. These are prepared now by our own staff, but in the past they were prepared by the Secretariat, working for us.

You see, the Science Council did not come in at the beginning of scientific research in Canada. We were created two and a half years ago to try to give advice to the government on a stream of scientific activities which were going on and which on the whole were pretty satisfactory.

So, we have viewed our job as first trying to find out what was going on by a series of inventory studies and then by trying to give advice as to how to change this flow of activity in order to bring it more closely in relation to the national goals and the economic and social problems of Canada. So we have not in

a sense originated new programs; we have merely tried to recommend how on-going things could be beter done, better organized and better carried through to completion. We cannot say that we started a project and that the project has gone so far, because in every case so far we have really been commenting on things that were already going on.

Senator Thompson: But in your study, you have chosen a major program of water resources research. How was that initiated? Why did you not choose air pollution research? Why did you decide on water resources research, and then where did you go from there?

Dr. Solandt: We chose this, if my memory serves me rightly, which it may not; let me see, when did it start?

The Chairman: With the Science Secretariat.

Dr. Solandt: Yes, but I was trying to remember whether it started before the Council.

The Chairman: Before.

Dr. Solandt: I think it did; so that we cannot claim credit for having reached this decision, although I think that it is quite a sensible decision, because we do have a great deal of water in Canada. Our neighbours to the south are eyeing it very enviously and, as you know, there are a good many projects being discussed in the States for diversion of water from Canada. Certainly in discussion at the Council we have felt that we ought to push forward with a knowledge of what our water resources are, how we are going to use them, and what we need them for ourselves, because we are going to be under pressure from the U.S. to share our resources with them and we will be in a much stronger position to resist this, as I think we should, if we really know what we are talking about.

So this is an argument for giving priority to water resources, rather than air pollution.

Senator MacKenzie: Could I add footnote there: This was before the Council came into existence. I do know that correspondence was directed to both the Prime Minister and one of his colleagues urging the carrying out of studies in this area, either under a Joint Committee or in another way. I assume that one of the reasons that the Science Secretariat, as advisors to the Prime Minister and the Cabinet, came up with this was in part because of this urging and this pressure.

Dr. Solandt: Dr. Maasland, you were in this almost from the beginning, were you not?

Dr. Dirk Elbert Leo Maasland, Science Advisor, Science Council of Canada: Not quite, but I have heard these contradictory stories.

The Chairman: I am under the impression that the space program study and this one on water resources research and management were initiated by the Science Secretariat before the Science Council was established.

Dr. Maasland: This is my original understanding, but it is not the way it has appeared in the report.

Mr. James Mullin, Secretary, Science Council of Canada: In the records of the Science Council the space report was certainly under way when the Council was created, but at the first meeting of the Council it was the President of the Royal Society who asked the Council to consider intitiating a study of water resources, because the Royal Society was concerned and he as an individual professionally was also concerned since the Department of Energy, Mines and Resources have responsibility in that field.

Senator Thompson: Mr. Chairman, I was really following Senator Hays' question. You must hear from a number of vested interests, in the high sense of the word, people with a particular interest, such as the President of the Royal Society, and so on. There are many studies that you could consider—safety of automobiles, and a whole variety which are certainly in the national interest—and I was just wondering how you arrive at the study which you will undertake which study you will take?

Dr. Solandt: Well, as I explained earlier, and as I think our last five-minute discussion makes perfectly clear, the Science Council started in a slightly confused state by taking over a series of projects of studies that were in different stages of development by the Secretariat. Since then we have been struggling, I think recently with some success, to try to get a much more orderly and coherent program in which we try to assign priorities within our own work, the jobs that we think are most important, and we have in fact now a list of priorities for discussion at the Science Council meeting next week, to decide

priorities for at least the next year. We have to just choose the number of subjects that the staff can handle in the time alloted.

This is our limitation, because there are, as you rightly say, a hundred subjects that we could start on and we have tried to pick out the ones that seem most important to us in Canada and that we can most likely achieve something on in the near future.

In this sort of thing it is very important that there be a promise of some possible action. I always take an example of this: if one did not take this into account I think all science programs would include a study of perpetual motion or anti-gravity machines, because these obviously would be very valuable discoveries, but since we have no prospect of making any progress in that direction we simply leave them off.

Senator Hays: Can we take an example, a study like the Saskatchewan-Nelson River Basin Study, which is concerned with water?

The Chairman: Not the south Saskatchewan dam?

Senator Hays: No; it really is the conservation of the water on the eastern slope of the Rockies. Would you be dealing with this?

Dr. Solandt: I would not expect so. It would fall clearly in our major program of water resources research and would be considered as a part of that.

Senator Hays: Getting back to my original question, there is no program that you can follow through at this point then?

Dr. Solandt: No.

Senator Hays: You cannot say, "This program was suggested and initiated by so and so and we have made a study and this is the recommendation we are making to the Treasury Board or the Prime Minister, or any Minister"?

Dr. Solandt: Oh, we can follow some through from the initiation of the program to recommending to the Prime Minister. I thought you meant to action and completion.

The Chairman: Take the space program.

Dr. Solandt: The space program and the water resources programs are good examples. They are the two programs for specific action that we have carried through and made recommendations on.

Senator Hays: And you have already made these recommendations?

Dr. Solandt: Yes.

Senator Hays: And whom do you make these to?

Dr. Solandt: To the Prime Minister. And they are published at the same time.

Senator Hays: Are these on a priority list, 1, 2 and 3, in relationship to the amount of money that you have to spend?

Dr. Solandt: No.

Senator Hays: Are they looking for that sort of information?

Dr. Solandt: Yes, the President of the Treasury Board would like to have a list with every scientific activity in order of priority with a running total of expenses down the column, and when he decides how much to spend he takes a pair of scissors and cuts the list off at that point.

The Chairman: That is a typical Treasury Board approach.

Dr. Solandt: But this is a totally unreal idea, because obviously so many of the projects in science are inter-dependent and if you are not going to do this one, then it is not worth doing that one, and if you are only going to do half of this, then you will do this one instead of that one, and so on.

So that any decision on priorities must be a sort of circular process, that Treasury has to say, "Well, we have only got so much money. What things do you think we would cut off?" You come back with a list and they say, "Well, that is not enough, cut off another."

Senator Hays: Do you go so far as to tie them to future economic benefits which would give the Treasury Board some indication as to whether it pays to go ahead with this sort of a program?

Dr. Solandt: We have not. In both these two cases where we have come closest, the space program and water resources, we have tried to give a rough estimate of what the economic benefits are, but in nearly all these things there is a mixture of tangible and intangible benefits. In a thing like clearing up water pollution, how much value do you attach to it? I do not know. If you just put it in dollars and cents, it is not worth much, but if you put it in terms of improving the environment it is worth a lot.

The Chairman: Are there any other questions on this vein?

Senator Yuzyk: I would like to ask a question about a Minister without Portfolio in charge of science. Since many of these recommendations will cut across various government departments, in order to carry them out somebody will have to be responsible for the whole project. I understand that at least some members of the Science Council consider that there would be advantages to having a Minister without Portfolio in the Cabinet who would be responsible for science. What would be the advantages and disadvantages?

Dr. Gaudry: The one great advantage of having a Minister without Portfolio is that he is not responsible for a large scientific staff, so he does not run into conflict with the interests of his own department. He can take a more detached view. We were only looking for somebody to carry the responsibility of selling science to the Cabinet and its implications and the needs of science in the country. We are not saying that this should be necessarily a minister, but we have not found an easy way to establish a proper liaison between the Science Council—

The Chairman: Do you mean that the alternative is to have another public servant?

Dr. Gaudry: I do not know what the alternative is.

Senator Yuzyk: Well, I think the government would be interested in having somebody who would co-ordinate such policy if the Science Council of Canada would strongly recommend it. I do not know whether the Science Council is recommending it, but I know you are discussing the matter.

Dr. Gaudry: We are discussing it, but we are certainly not recommending it at the present time.

Dr. Solandt: No, the situation is that we have been discussing possible mechanisms for the moment and if we were firmly convinced that we knew the right answer we would come out with a firm recommendation, but I am not certain that we have the right answer. The idea of a Minister without Portfolio seems to be the most popular suggestion at the moment. Other possibilities are that the President of the Privy Council would perform this task, but he is very busy with other things and would probably suffer much the same difficulty as the Prime Minister himself in just not having time.

Another possibility is that whoever is Chairman of the Privy Council Committee for Scientific and Industrial Research could be the spokesman for science policy. This is the inherent difficulty, that it is very hard to find a Cabinet Minister who is interested in science to be Chairman of this Committee who is not himself responsible for one of the departments that is a major contender for funds, or the present situation where you have the President of the Treasury Board in this position and he is the major stopper of funds for everybody.

Senator Yuzyk: I still think the government has to look to the future, and even if we are not sure at certain stages, as you evaluate many other projects, it might be worthwhile starting. Surely they could find someone within the Cabinet who has quite a knowledge of science in general and would be in close communication with the Science Council and other Canadian bodies. He would have all of this at his fingertips, and in this way it would be much easier to promote certain policies.

Senator Grosart: The problem would be to get him elected.

The Chairman: Why?

Dr. Solandt: Mr. Chairman, I feel sure that the government is very hopeful that your Committee will include recommendations on this in your report, because it is a very difficult problem and one in which your wisdom would be most helpful.

The Chairman: I think it is within our terms of reference.

Senator Grosart: But if the suggestion of a Minister without Portfolio found favour, what would be the objection to calling him Minister of Science as he would be called in popular, in the Press anyway? Would there be any objection to calling him the Minister of Science, without setting him up with a secretariat.

Dr. Solandt: I think the purists would prefer to call him Minister for Science Policy.

Senator Grosart: Yes.

Dr. Solandt: I see no objection; in fact, I personally do not see any grave objections to setting him up with a staff.

The Chairman: How can you expect a minister to work without a staff?

Dr. Solandt: You cannot, and I do not see any grave objection to having the Science Council advise him; it seems to me that this would all fit together quiet well.

Senator Grosart: Would you see him having a responsibility to assist the R & D programs

of all the departments and all Crown Corporations and all entities spending government money?

Dr. Solandt: Yes, in an advisory sense. I think it would be very difficult for him to do it in an executive sense, because he would then become the Minister for Science and would control the science in every department.

Senator Hays: Dr. Solandt, are you familiar with how the American space program got off the ground?

Dr. Solandt: Not in detail; I have a general knowledge. As I understand it, it was very largely the initiative of people in Congress; I know the NASA administrative people give great credit to the Congressional Committees for inspiring this program, although I think others give most credit to the Russians.

The Chairman: To Sputnik.

Senator Cameron: Dr. Gaudry made a remark this morning that intrigues me, because I have been thinking about it in another capacity. He said, and I thoroughly agree with him, that the statistics we are getting are too old to enable the Council to make good recommendations. This I agree with, and this is no reflection on the Dominion Bureau of Statistics, but by the time we get them they are so far out of date that...

The Chairman: Why is it not a reflection?

Senator Cameron: Well, they do a good job up to a point. Perhaps it is our fault that they are not doing more, that this has not been brought up before, but I am sure that in the terms of the needs of today there has to be a major overhaul of that bureau so that the statistics are more effective.

What can we do about it? Have you any suggestions as to the kind of effective statistics you want and how we can get them?

Dr. Gaudry: When we do get very precise statistics, because they are very precise they are old and therefore not very useful in proposing changes in policy and especially expenditures. We need a system whereby we would have rapid access to trends; something that would be current even if not precise. How one goes about getting that, I am not sure.

The Chairman: How is it we get current figures on many sectors of the Canadian economy, but not in your case?

Dr. Gaudry: Well, I am not familiar with the way the Dominion Bureau of Statistics is actually operating, but I am sure that some mechanism can be found to provide not only us but the government with very up-to-date information, even if not very, very precise, at least reasonably indicative of the trends.

Senator Cameron: This leads into something else again, Mr. Chairman. When the atomic energy people were here the other day I raised the question of the need for rapid information retrieval machinery, the kind of thing they have at the Strategic Air Command at Omaha, Nebraska, or Colorado Springs, which is the most effective and up-to-date I have seen.

This ties in with getting statistics; the same principle would apply, which suggests to me that here is where the computer comes in. We have to get more computers, and the people to run them and handle this great volume of new information which is constantly coming out. This means training people in the science field who can abstract and condense the tremendous volume of information that is coming out from all over the world and put it in a form that the ordinary person can use.

So this question of statistics is only part of the larger problem and, as I see it, in the one area of information retrieval. Have you any suggestions on how we go about this, because I am sure we have got to do it.

Dr. Gaudry: Well, the Science Council has a study under way on information.

Senator Cameron: Yes, I know. It is referred to.

Dr. Gaudry: At the meetings of the Science Council we have not yet discussed that in detail as far as I can remember.

Dr. Solandt: No, it should be before the Council, not at the meeting next week but the one after that. I would answer your question more generally to say that it seems to me that the time is ripe for some very major action in this field in Canada. We have been relatively backward. It is interesting that private enterprise is beginning to enter this field very actively. I do not know if you have noticed that there are computer utilities operating in Ottawa now, and bigger ones are starting. This might conceivably be done through private enterprise, but there are at least two needs that we have in the country: One is for an information system.

You are all familiar with the fact that Canada is really ill-equipped with libraries;

we only have one university library that even approaches the standards that are set by the big libraries in the United States. I refer to the University of Toronto library, but it is not very good by American standards. I do not think Canada will ever get a series of first-class libraries all across the country. With technology in the state it is in now we should never aim at that. What we should aim at is having in the nation the best total collection in the world, which would be quite a reasonable aim, and have different universities and other centres be specialists in certain fields. For instance, UBC might have the biggest oceanography library in the world, and so on, in different places, and have them all interconnected by a data transmission system so that this information would be available everywhere. You cannot quite do this today, but very nearly and, by the time we get in planned technology will certainly be right abreast of our need.

We could also aim at putting in a national data bank. We have started in a very modest way and the main economic time-series are available in a computer in Ottawa. But the kind of thing you are talking about in the line of statistics could conceivably be available in time. All major things like university statistics, and so on, could be put into the computer so that you would know how many students there were in the universities the day after they registered.

The installation of these systems is costly and the period of overlap while you are still using the old system and the new one as well is very costly, but once it is installed and working you get very good data, much better than you ever had before, very much more quickly and more cheaply.

Some enthusiasts have even said that an area in which Canada might develop an export market—I see some other nations are talking about it—is setting up data banks for particular fields which would be interrogated by people all over the world at a fee.

I have mentioned before and will repeat again that we have in Canada absolutely first-class people in these fields, and if we gave them the challenge they could do these jobs. Challenge in this case means money.

Senator Cameron: Just because you put it in this context of money does not this suggest that we are never going to have enough money. To do the job effectively we have got to find some formula for mobilizing the total forces, just as you suggested, develop areas of specialization, but tie them all together so that our total program is moving forward as a unit.

This also relates to the next step, that again because of the money limitations obviously Canada is not going to be able to do all the R & D that needs to be done and we should never contemplate that, but what facilities are available for the international interchange so that we can draw on the work that has been done in other countries so that we do not have to duplicate the work that is being done?

Dr. Solandt: As you know, the exchange of information through scholarly publication is very good, but very slow. There are also major moves to improve this and Canada is on the fringes of these. Many of the major abstract journals, for instance, are now published on magnetic tape and so are available in much more readily usable form than they used to be. The Library of Congress catalogue comes out on magnetic tape now and can be used for a fraction of its former cost.

Senator MacKenzie: Does classified information affect this exchange of international knowledge?

Dr. Solandt: Remarkably little; as a percentage of the total, much less than it did a few years ago.

Senator MacKenzie: Is this true of industry as well, or are they concerned about protecting their patents, and so on?

Dr. Solandt: Oh, no; there is still a great deal of proprietary information in industry that is not widely circulated. Even here I think it is a lot less than it was. Many of the biggest industries now have a policy of either using the discoveries they make for their own purposes or else publishing them, on the grounds that patenting them is just too much trouble unless you are going to use them yourself, but you make so little money out of them that you might as well publish them. This is not, of course, the universal rule.

I would say that both industrial and military secrecy are a smaller percentage of inhibitor of free interchange than they were even ten years ago.

The Chairman: I think we have more or less reached the point where we should go into an examination of the report in greater detail, but before we go into this more

detailed exercise I would like, in order to focus our discussion of the Council's report, to be the devil's advocate for a moment or two.

Senator MacKenzie: Before you do, could I ask a question, Mr. Chairman: How long do you intend to carry this on tonight, because one of our guests has to drive to Montreal?

The Chairman: Certainly not later than ten o'clock.

Senator MacKenzie: Thank you.

The Chairman: It will, of course, depend on the comments that my statement might cause from our two guests.

Senator MacKenzie: Could I ask a further question related to that: It is conceivable that we might like to have representatives of the Council come back again in a few weeks' time. Would you explore this in due course?

The Chairman: I understand that Dr. Solandt will be available tomorrow.

Senator Bourget: All day tomorrow or tomorrow morning?

The Chairman: All day tomorrow and, of course, if this is not sufficient, I am sure they have been so nice to us that they will not hesitate to come back at a later date.

Senator Bourget: So we will be able to ask some more questions on the brief?

The Chairman: As I just said, I thought that I would make the statement on the report before we go into a more detailed examination of it.

Senator Bourget: Yes, but I am talking about the brief, Mr. Chairman. I thought we would first dispose of the brief.

The Chairman: Well, if there are any further questions on the brief, this is the time to put them.

Senator Bourget: All right, you carry on and I could ask on some other items which appear in the report.

The Chairman: Yes. Well, in my new role as the devil's advocate I would like to make a short statement on what is in my view the nature of that report and possibly its limitations. At best I think, and in this I am sure I reflect the views of the Council, this is an interim report. I am sure that the Council would agree with that view, because the title of the report itself is "Towards a National Science Policy for Canada." This very title seems to suggest the idea that this is an interim report, that this is only one report in a series of further recommendations that the Council will make.

To illustrate the limitations of the present report I would like for a moment to list the elements of a national science policy which are explicity or implicity excluded from the report. In the first instance, and I must admit that we have had a lot of discussion about this report itself, the Council does not deal with the overall structural organization and administration of science policy. It proposes the creation of new research agencies, but it has little to say as to how at the policy level our scientific effort should be defined, co-ordinated and implemented.

More particularly, the Council does not attempt to answer the basic question whether or not there should be a central focus for the formulation of science policy and where that focus should be located. Again I want to emphasize that I am dealing with the report and not with our discussion this evening.

In the second place, the Council devotes just a few paragraphs to what should be our target for a maximum science budget which could be spent if there were enough worthwhile programs that could be usefully undertaken in Canada. The Council's approach to this basic problem is in my own view at least, and my views are never final, unduly negative.

Its conclusion on the matter appears at page 52 of the report and is as follows:

> The funds which are allocated to scientific activities annually should be granted, program by program, in face of competition from other potential uses of these funds, with each program justifying its expenditures on economic, social or cultural grounds.

Members of the Committee may want to ask questions about this later on, but this method of arriving at a science budget appears to me to be the negation of planning, and it precludes the application of any satisfactory workable system of priorities. If I interpret that paragraph correctly, it involves comparisons, let us say, between ING, the PEI causeway and a similar amount of money spent on external aid.

Who is going to decide whether or not a given program is justified as compared with all the others submitted to the government on

economic, social or cultural grounds? Certainly not in my view the Science Council, for it does not have the information and the expertise to make such decisions or such recommendations.

In my view the Council's approach to budget making will have to be greatly improved if we are to have a science policy at all. In this respect I would point out that Belgium, it seems to me according to what Dr. Spaey had to say, has made more progress in improving this approach than we have in Canada.

In the third place, the Council does not cover the social sciences except to say that they should receive more assistance. Again I understand that this was an explicit exclusion from your report because of the kind of grey area in which the social sciences are at the present time. I fully understand the Council's position in this respect, because as it has been constituted those sciences appear at least to lie outside the terms of reference of the Science Council. But, given this serious limitation, how can we expect the Council to develop a balanced and realistic science policy at a time when the basic problem is not technological change itself but the adaptation, as Senator MacKenzie was saying this morning, of man and his institutions to that change which is becoming, as we all know, more rapid and radical?

How can we with that kind of vacuum establish priorities for science policy when we have no information, no real discussion of this whole field of the social sciences?

In the fourth place, the report does not deal with basic research and little science and, of course, this again is an explicit exclusion made by the Council very consciously. As I have just said, the Council is very conscious of that gap, but the fact remains that this important element of our scientific effort is not covered.

Finally, the auxiliary services and programs of a good science effort and policy receive in the report only brief references. We have evidence, for instance, before us that a serious surplus of research manpower is developing in Canada, and yet government agencies continue to devote large sums of money to the training of such manpower. Will we have to wait for the detailed studies by discipline that the Council is contemplating, but which have not yet been initiated, before the government can take any corrective action? What will happen in the meantime to those students and young scientists who will have been misguided by the government's incentive programs?

An effective and highly developed scientific and technological information system, as the Council says, is an auxiliary service which is essential to a realistic formulation and implementation of science policy, especially in a country like Canada. This point is made in the central paragraph of page 4 in the report. But the Council is awaiting the conclusions of a study being made by the Secretariat before making specific recommendations on that most important aspect of our research strategy, but if we are to avoid duplication in this international scientific race and if we are to establish priorities for Canada, how can we establish those priorities if we do not have this kind of essential service to which Senator Cameron referred a moment ago?

These are some of the important explicit or implicit gaps of the Council's presentation which in my view make it at best an interim report.

What is then the object of that report? Its purpose is to deal with applied research and development in the field of the physical and life sciences. In this respect the Council makes two basic recommendations:

First, the emphasis should be put on development work made by industry; second, most new research undertakings should be organized as large, multi-disciplinary, mission-oriented projects having as a goal the solution of some important social or economic problem.

The first two such programs which are recommended are related to space and water resources management and development. I am sure that members of the Committee will want to ask detailed questions about these two basic recommendations.

What kind of financial incentives will induce industry to play a much greater role in our scientific effort? Will fiscal incentives be enough to achieve that goal? What about the managerial gap that has developed between the United States and the rest of the world which was described I think very well by Schreiber? Incidentally, I was delighted to see that you were quoting Schreiber at one stage in your report. What about the managerial gap which is developing and which may as a result make our own managers in private industry less aware of the importance of research and development in our country?

If the large, mission-oriented programs envisaged in the report are to become the centre of our new scientific effort, is the Science Council really qualified as presently composed to determine our main economic and social problems? For instance, did the Council select space and water resources on the basis of a rational system of priorities, or merely because these two subjects were the first to be studied by the Science Secretariat?

These and other questions will certainly be raised during the discussion period, but before we reach that stage I wanted, to make this opening statement and to be for a few minutes the devil's advocate and put the Council's report in what I think is its proper perspective.

That report deals only with one sector of science policy and as such, while it is most useful, it can hardly constitute in my view the basis for a new science policy for Canada.

Senator Bourget: Mr. Chairman, what do you really mean with just one aspect?

The Chairman: Applied research and development in the field of the physical and the life sciences.

Senator Bourget: Well, then, if you look at the orders of reference I do not see that much blame could be put on the report of the Council the way we look at it. I think you made good remarks and I agree with them...

The Chairman: No, this is not a blame on the Council.

Senator Bourget: No. Perhaps I did not use the right word, but you know exactly. Between French Canadians we understand each other.

The Chairman: But then, you see, in order to understand each other as French Canadians you should follow the advice of René Levesque and speak "la langue de la confidence."

Senator Bourget: No, but I just wanted to know exactly if the preliminary report of the Council should touch only the terms of reference that they had from the Privy Council?

The Chairman: No, I do not think that they have covered the whole field of the terms of reference.

Senator Bourget: Oh, well.

The Chairman: But in the conclusions which I have mentioned there were things which are ouside their terms of reference but which belong in my view to a national science policy.

Senator Bourget: I agree entirely with the last part of your remarks.

Dr. Solandt: Well, to sit on the other side of the argument.

Senator Grosart: We will give you equal time.

The Chairman: Yes, before going into detailed analysis of the report we want to have a good forum.

Dr. Solandt: In quoting the title of the report you have really, to use a slang expression, pulled the rug out from under your other comments. I agree with most of them, although a few I will be critical of, but certainly the things you have pointed out as missing certainly are missing. There is no doubt about that.

As I said before, we visualize the Science Council coming in as a policy-forming, guiding mechanism, if you like, trying to guide an on-going stream for research and development. We are not saying, "Look everybody, stop work until we can come out with the policy." What we have done here is to try to recommend the changes that we think need be made, and the changes are really changes in outlook and approach to problems and there will be more specific recommendations for specific programs following. The changes that need to be made or to redirect the stream of scientific activity in Canada so that it will be more meaningful to the social and economic progress of the country than it has been in the past.

That is, this is a report that does not pretend to cover the whole range of science policy; it just says let us make these changes while we are busy studying the other problems, because these are things that we have by now become convinced need to be done. We will come along with other things afterwards and science policy will be changing all the time. There will never be a definitive science policy, any more than there is a definitive national policy for all the problems of the nation.

So while it would be nice if we could have come out with a much more complete report, we felt it was important to come out with a report now which does recommend changes that we think are necessary and will be useful.

Of the shortcomings that you list I would agree with you that one of the very important

ones is that we do not specify what you would have called the overall policy-forming mechanism that should be adopted. But I think the discussion we have had here makes it clear why we did not, because we are not really sure of what it should be and we have been told by a good many people that if we just wait, your Committee will tell us.

The Chairman: I thought there were no leaks in the Senate.

Dr. Solandt: I think you were fairly charitable about our section on expenditure. This was the subject of more debate than any other thing in the Science Council. I shudder to think how many times it has been re-written. Jim Mullin has re-written it three or four times and he was not the first to write it. Our difficulty was that there was really very serious disagreement. There are two schools of thought on this problem of how you specify a broad general budget for science: One is to say you pick a number between 1 and 10 as a percentage of the gross national product and say that is the target. You can pick that number either by comparison with what other countries are doing or by comparison with what we ourselves have done in the past or by looking, as we have in one report that is coming out soon, at what it would cost to employ the people that we are likely to have available to us in the future. Or you can do it, as has been suggested here, by deciding what things you want to do and then finding out how much it is going to cost and saying "Well, that is the research budget."

The way it has been portrayed here is certainly not very satisfactory, and it is to be hoped that one would never consider reassessing every science program every year. That is badly worded, and it was not the intention. The intention was that the annual budget will be made up of the costs of a series of programs which have been considered in relation to competing items of expenditure, but not every year. Once you decide that you are going ahead with a program, you weigh it carefully against alternative means of using the money, and if you decide to go ahead with it, then you go ahead with that program until it is finished. So that sentence is badly worded; I had not realized that it is quite ambiguous and could be taken the way you did.

We hope that we will be able to do a better job on dealing with expenditure targets and ceilings in the very near future. We have got a good deal of work going on it; one paper, which is a background paper for one of these approaches, is in press and will be out about mid-December I think, and we will send it to you.

You commented, again, on the fact that the social sciences are not really included in this. We just say that we have omitted them, and that this is a very serious omission. I think this is one problem that must be solved and one which again this Committee might very well take leadership in and, as I see it, there are several alternative courses of action.

One would be to just add a few social scientists to the Science Council so that we could say that our recommendations, while they did not cover the social sciences, were at least intelligent from the social science point of view. The next possibility would be to dissolve the Science Council and form a new science policy council that contained a proper balance of natural and social scientists. Another possibility would be to form a parallel council for the social sciences and possibly put on top of the two of them an executive committee, or something of that kind, that had representatives of both of them and that might be chaired one year by the chairman of one and the other year by the chairman of the other. They would co-ordinate their work, and they could also have their staffs working side by side in the same building. These are alternatives that need to be considered, but I think it is quite important that something should be done.

You mentioned our lack of support of auxiliary services. We certainly did not intend to short-change them, and again they are covered by one brief boost, just in passing really.

As to the question of surplus students, we have been quite concerned to hear of the evidence that has been presented to you, because we certainly in the studies and discussions we have had at the Science Council see no evidence of a surplus appearing in the foreseeable future.

The Chairman: Well, you have seen the presentation we received from the National Research Council.

Dr. Solandt: I have not seen the actual presentation that came here, but I have seen the figures.

Senator MacKenzie: It was Dr. Gray, was it not?

The Chairman: No. Dr. Gray referred to this, but the National Research Council provided us with a graph, and so on, showing this developing surplus in the field of research scientists and engineers.

Dr. Solandt: I have seen the figures and the graphs and I do not think that they are correctly interpreted. It seems to me that what is being said is that for the first time our domestic production of Ph.D's is going to exceed the past domestic consumption, but Canadian universities, just to take one employer, have been desperately short of Ph.D's for years. In many branches of science 25 percent, 50 percent of all people in our universities are not Canadian-educated, so if you look merely at the Canadian Ph.D's that have been absorbed into our society and say that we are going to produce more in the future than we have had in the past and that we will have a surplus, this is quite misleading.

The Chairman: They presented two charts to us which forecast both supply and demand.

Dr. Solandt: Yes.

The Chairman: And the comparison between the two really showed a developing surplus.

Dr. Solandt: Yes, but again, you see, this demand is based on the way in which Ph.D's have been used in the past; for instance, we have practically no Ph.D's in industry compared to other highly developed nations, particularly the United States.

I think that what will happen is that these Ph.D's will go into industry; they will go into a wide variety of other occupations. They are not going to be unemployed.

The Chairman: I hope not.

Dr. Solandt: The percentage of the number of university graduates in our labour force today is less than half of what it is in the United States, and we think that country is much more productive than Canada. It has got a more educated labour force, and yet here we are getting panic-stricken because we are beginning to catch up on them.

The Chairman: Well, as I pointed out to both Dr. Shneider and Dr. Gray, in the United States they are forecasting a developing deficiency in this field.

Dr. Solandt: Yes, and they are producing relatively far more than we are. Take scientists and engineers in research and development occupations; we have about 14 percent of the scientists and engineers in Canada in research and development; the corresponding figure in the United States is about 30 percent. The percentage of scientists and engineers in our labour force is just a third of the percentage in America.

The Chairman: I do not want to pursue this discussion for too long but I understand, for instance, that the National Research Council has made a very systematic study of this problem and apparently this study, which was done under the direction of Dr. Bonneau, is going to be published later this year. Are you aware of that study?

Dr. Solandt: Yes, I knew it was going on and I think what we must do is get together with them and see what is wrong with the two points of view.

We do not see any danger of a general surplus. We do see that we are going to have a real problem in the future, as we produce more scientists and engineers, of getting them into the right special fields. This is a very difficult problem and involves poor statistics and slow development of information. It takes so long to find out that you are short of a particular special field that by the time you find out it is too late to get people in. You just get them started and the shortage has passed. We have got to find a better method of trying to influence the specific fields which people go into, but we are not apprehensive about a general surplus.

Senator Cameron: It was an interesting thing, Mr. Chairman, that when that statistic came out about 11,500 Ph. D.'s graduating in Canada in 1973, we had people from the National Research Council, the Atomic Energy Commission, and Canadian Patents and Development Limited, and practically none in that whole group in front of us had a Ph.D. I realize that those persons are products of 20 to 25 years ago, but most of them just had a Master's degree. It raises the question as to the proportion people who should be graduating as Ph.Ds' and Masters and where they fit into the pattern of demand.

It is a rather amusing commentary that we are going to have 11,000 graduates who are Ph.D's, but none of the peope who are putting the figures out on that, who have top positions in the National Research Council and other positions, have a Ph.D except Dr. Shneider.

The Chairman: Senator Cameron, I would suggest that we might come back to this. We will have all day tomorrow on all these areas, and I am sure that in the meantime Dr. Solandt may very well go back to the presentation that was given to us by the National Research Council so that we might go into greater detail in this area tomorrow. We still have about seven minutes left this evening, and I understand that Dr. Gaudry would like this time for rebuttal.

Dr. Gaudry: Well, just on two questions raised by yourself, Mr. Chairman, on the question of the surplus of scientific manpower. I feel very much like Dr. Solandt, that we have been terribly short of highly trained people in industry.

I was in contact for many years in the pharmaceutical industry with large companies in Europe. Their experience both in England and on the Continent was that over the years only a very small proportion of the Ph.D.'s hired for the research laboratories stayed in research. They went into production, sales, development, and all kinds of activities. This put a tremendous amount of drive into these organizations, and I would hope that this would be the case here.

We may have a surplus of manpower if we only use Ph.D's the way we have been using them in cases of very acute shortage in Canada, but I am very hopeful that some day we will have a few extra Ph.D.'s to put outside of research, at least, outside the bench and the laboratory.

Senator Grosart: You mean if we have a surplus they will have to go to work.

Dr. Gaudry: That is right, exactly; as a matter of fact, I am really looking forward to that time.

The Chairman: Do you think they would make efficient salesmen?

Dr. Gaudry: You would be surprised.

Senator Grosart: There is a very interesting American study showing the entrepreneur aspect of the Ph.D.; it is a tremendous story. I have forgotten what study it is.

Dr. Gaudry: I have seen some too. I would like to review in detail the arguments presented to you by the National Research Council, but I just so far tend to disagree completely with that view.

I would like to say one thing about basic research and little science: There is a study under way on the support of research in the universities, and this we think would lead to the same recommendations to the government next spring, but here for the first time we have tried to work very closely with the social scientists. It has not been easy, but we think we have managed.

Senator Thompson: So that on basic research you are working with them?

Dr. Gaudry: We are certainly going to come up with very comprehensive views as to what amount of basic research and little science is going on and how well or badly funded it is, what are the gaps and what should be done to cope with the existing problems that we will point out. I would like here to say one thing: There has been over the years a large number of departments in the federal government that have been supporting research. They have been supporting basic research and little science mainly in the universities without any co-ordination whatsoever between all these various departments in the methods of granting, in the levels of granting, in the areas which should be supported, and how much, and so on, and some of these ad hoc decisions made at the departmental levels have created great problems in the universities.

I will give you one example. One department pays the head researcher, a Ph.D. who does the work, over and above his university salary, while others do not do that at all. So here is a man with many thousands of dollars over and above his salary and we have no control whatsoever over that. Whether it is good or bad is not the point. I am just saying that co-ordination is essential in basic research and little science, not only in the big science which involves government, industry, and so on. I am just saying that a lot of work is being done at the present time in this area, and I think you will hear from the Science Council fairly soon in this connection.

The Chairman: Honourable senators, I think that we should adjourn at this point. On behalf of the members of the committee I would like to express our gratitude to Dr. Solandt and Dr. Gaudry. The committee will sit again tomorrow morning at ten o'clock and if we do not get through with our detailed examination of the report we will have to adjourn its consideration to a future date suitable to the Science Council.

Again, Dr. Gaudry, merci beaucoup; Dr. Solandt, thank you very much.

The committee adjourned.

MORNING SITTING

(Third and Final Session)

Ottawa, Thursday, November 7, 1968

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, this morning we might resume from where we were last evening. You remember we were discussing the confusion about forecast of manpower supply and the demand for scientific manpower supply in Canada. I understand that Dr. Solandt has done some work during the night and he is now in a position to make a statement on this.

Dr. Omond M. Solandt, Chairman, Science Council of Canada: Thank you very much. I would not over-estimate the importance of the homework we have done. It is really a very quick look at the facts, as we have them available, and I will emphasize later the need for further analysis. The picture in Canada today as I see it from the point of view of the production of highly-skilled graduates in science and engineering, particularly Ph.D.'s, is that we in Canada decided some time ago that one of the problems we had in Canada and one of the reasons, for instance, why our productivity was so much lower than in the United States was because there was a lower average level of education in our labour force and a lower percentage of university graduates in the labour force, particularly in management and entrepreneur jobs. As a result, we have in Canada in recent years been investing a huge amount of money in education.

One has only to look at recent statements by the Minister of Finance to find that these expenditures have even been higher than were expected. Inevitably since we have had this very rapid expansion in the number of students at the universities, we have also had a very rapid expansion in the number of teachers in the universities, so the universities have in the past few years been tending to absorb a very large part of the Ph.D.'s that they are producing and I might say, as an aside here, that because of this they are tending to train the Ph.D.'s for an academic life because this is where most of them will be employed anyway. I think this is one of our real problems.

As I see it, what was presented to you by the two previous speakers, by both Dr. Schneider from the National Research Council and Lorne Gray from Atomic Energy of Canada Limited, was merely the picture that for the first time, some time in the next couple of years we will begin to produce enough Ph.D.'s in our expanding university system that a substantial number of these Ph.D.'s will get out of the universities and be available for employment outside.

Senator Grosart said some of them will have to get to work. I think this is a slightly cynical point of view. I have known a lot of university people and they really work very hard.

The Chairman: He would not be elected a regent very soon.

Dr. Solandt: I think we should not regard this beginning surplus of Ph.D.'s with apprehension; we should regard it with satisfaction. This is what we have invested our money for. What we have been trying to do is to get these highly educated people out of the universities and available for introduction into our economic system, particularly into industry, and it seems to me that the graph you were shown of Ph.D. output in new employment is extremely pessimistic, because it shows in the years after the present, practically no increase in employment of Ph.D.'s either in universities or in industry, just a trivial increase in employment.

We certainly have made a terrible mistake if these people are not going to be employed, but I do not for a moment believe that they will not be fully and well employed. Mind you, the fresh Ph.D. is not going to have it all his own way as in the past. He may have to go looking for a job and sell himself to somebody in industry, but this will be very good both for himself and for industry. I am very confident that these skilled people will make a tremendous mark in industry.

Let us not conclude that these people, in going into industry, have to go into research and development. Possibly some of the Ph.D's being developed now do have the attitude that because they have been trained as research workers and engineers they will have to work as research workers or engineers. I know this is not true in the case of Ph.D.'s in industrial engineering, and there are other fields in which the Ph.D.'s are prepared to go into industry and work at other jobs.

You have only to look at the statistics for educational levels in industry to see the need. For instance, in Canadian industry today about 25 per cent of the managers have less than a Grade 8 education. Some, in fact probably all, of those people are exceptionally able people, because it takes real drive and capability to be a manager with less than a Grade 8 education. But we can certainly run industry better if we have better educated people. I am not advocating that all managers have to be Ph.D.'s but that the general level must go up. This will do a great deal to reduce the management gap.

Another point that was not emphasized in the N.R.C. report is that over half of the Ph.D.'s now coming out of our universities in science and engineering are non-Canadians. The figures here for 1967-68 show that only 49 per cent of those enrolled for a doctorate in science and engineering are Canadians, including landed immigrants. Of course, among that 49 per cent are quite a few who are not of Canadian origin but who have stated that they are going to become Canadian by entering in the status of a landed immigrant. The other 51 per cent are from other countries, and the greater part of them will go back home. Ten per cent, for instance, are from the United States, 6 per cent from the United Kingdom and 12 per cent from India. So that I am not even sure that the surplus of Ph.D.'s that we are looking at will really exist, but, if it will exist, then it is just in fact the beginning of a great opportunity we have been working hard towards, and paying out a lot of money, to achieve.

So what we have to do now is get busy and see that these people are effectively integrated into our labour force outside the universities. This can be done and will be one of the biggest elements in improving our whole situation over the next 10 years.

Senator Bourget: Mr. Chairman, regarding what Dr. Solandt had to say about education and engineering, I believe he referred to the output and formation of the special engineer-manager. I had the opportunity during the weekend to read a conference report by the Professor of Management at the Massachusetts Institute of Technology, Jay W. Forrester. With your permission, Mr Chairman, I would like to read a few lines from that report.

> Present engineering education may be satisfactory for providing a broad base of technical knowledge for our industrial society. But our educational system is not designed to produce the special engineer-manager with the high competence needed to integrate technology into our complex modern society.

I understand that he applied this to education systems in the United States, but, in your mind, does that apply equally to our educational system and do you think that there should be some changes in our educational system regarding the formation of what is becoming more needed, so far as I can see, namely, a special engineer-manager?

Dr. Solandt: Yes. If last night we had adjourned the committee to the Bar you would have heard a very learned discussion of this subject. The chief engineer of De Havilland, Dick Hiscocks, who is also a member of the National Research Council and very much immersed in this study, joined in an informal discussion at which we concluded, and I agree with the conclusion, that there are two directions in which our engineering education in Canada must have a different emphasis. One is to train the engineer-manager, and there is a good deal of emphasis being put on that now. Schools see the need for it. The other is training of engineers for the less exotic kinds of engineering that are so important to industry. For instance, Mr. Hiscocks was pointing out that when De Havilland wanted to get the hydrofoil, of which you have all heard, designed, there was only one person they could find in the world who could design the gear box. He was at General Electric in the United States. Early in the design of the gear box he had a heart attack and they had to just postpone the design of that grear box until he recovered and got back to work. Even a huge organization like General Electric in the United States did not have a second man who could design that gear box. This is a very highly sophisticated mechanical engineering device. If they wanted somebody to do solid state physics or theoretical physics or advanced mathematics they would have hundreds of them, but if they wanted somebody to design a gear box, a bit of highly sophisticated advanced mechanical science, they would have only one.

We need more facilities to train engineers for management and more facilities to train engineers for the kinds of engineering that are going to be done in Canada in the next few years.

Again, we had a long discussion of production engineering. This is another phase where there is very little emphasis in Canadian universities and where, for instance, it is impossible to get support for research. You cannot get support for research in either production engineering or design engineering unless you switch it round to make it look as if you are going to be doing something close to physics.

Senator Bourget: Thank you.

The Chairman: But if we have needs and scarcities developing in Canada, and you made this inference also, by consequence we might have in certain areas surpluses while over-all demand and supply would be more or less in balance.

This has some implication so far as the financial aid that our federal research agencies might give to one field or another. It seems to me that we have had manpower training schemes and we give scholarships for general purposes more or less indefinitely, irrespective of the requirements of the market.

Do you not think we should have a more flexible approach in our system of assistance?

Dr. Solandt: I am, personally, reasonably certain that over the next five years, say, we must try to evolve some system of guiding people into fields where opportunities will be available. This I know is regarded with disfavour by many people in universities, but the kind of thing I am talking about is merely that, if a person wants to go into science and engineering, then you can give him good advice as to what particular field will be most likely to need him when he graduates, and I think that the scholarships and fellowships and other supports should be weighted towards these fields and that it should be easier to get support for a field likely to be short than for other fields. This does not mean that nobody will be supported in the other fields, but he will have to be a better student and closer to the top of the class to receive support for a field that is oversupplied while if he is going into a field where there is a shortage he will get support although he may not be quite as good.

Senator MacKenzie: Mr. Chairman, as Dr. Solandt knows in medicine and dentistry, because of the limitations on space, universities have had to put limits on enrolments in these faculties. This is not particularly desirable from the point of view of the nation. Nevertheless it is done. The question I want to ask is would there be anything more offensive about the faculties of science, applied science and engineering doing the same thing in respect of, say, chemical engineering, if it was needed, or mechanical engineering, or what you will, or would it be more difficult at Ph.D. level? I grant you that the university could say "We only have sufficient accommodation for so many graduate students in this field" and in that way direct them into other fields where they are necessary but not oversupplied. Now this would be arbitrary, but since the situation is arising where the Government is going to be providing practically all the money for this kind of work, I think universities will have to take that kind of direction from government.

Dr. Solandt: I am reasonably sure that many provincial governments will start doing this. It is already being done to some extent in some fields. I was going to emphasize that one of the great difficulties is to get adequate information on what are the fields in which shortages are going to occur four or five years from now, and I think the control mechanism will be easier to operate than the information mechanism that tells us with reasonable certainty what is going to happen and what we have to work on. I might say of your suggestion that it is a pity that we have control or absolute ceilings on the numbers in medicine and dentistry that if Dr. Gaudry were here today he could tell you some horror stories of medical education in France where they have no ceiling. He told me of a university there, which shall be nameless, where they have 8,000 medical students enrolled with clinical facilities for only 2,000, and most of the graduates work in drug stores because they are not adequately trained to be doctors. I think in professional fields, especially in medicine where to be a good doctor you have to have practical training on the spot—and this is the thing that limits capacity—I think you have to limit intake. When you start to look at engineering the situation is somewhat the same. I think this is a thing we are going to have to face up to. It is a difficult problem. Various countries have tried it with none being really successful as far as I know. I don't know much about the experiments except what we hear about Russia.

Senator MacKenzie: You don't know how it has worked in Russia? I do know they have

been applying this kind of principle for many years.

Dr. Solandt: It really cannot go wrong because they decide where the people are going to work so everybody gets a job. However, I am sure there are troubles. Britain has been trying to make it work in a modest way by making the universities have a specified percentage of their places available for science and engineering as compared to the liberal arts and the humanities. This has in a sense worked, but it is much easier to get a vacancy in science or engineering in England now than it is to get a vacancy in other subjects. This shows that pressure is needed, and if they didn't have that pressure they might be getting far fewer scientists and engineers than they are now.

Senator Cameron: Mr. Chairman, I had made a note on this brief that there is not sufficient emphasis on training of managers and the machinery we need to do this. I was out at our own management school just last week, and I have been watching the curve there and the proportion of those in attendance who have engineering degrees is going up like this. This year it is 50 per cent. This has come up from about 25 per cent in the last five years. But I don't think you could do this in an undergraduate program. There needs to be some emphasis placed on engineering management at undergraduate level, but I think provision has to be made when these people get out and have a few years experience before having them brought back for training and specialization in the management development program. Don't you think this is the way this must be done?

Dr. Solandt: Yes. I am one who is very sceptical about undergraduate courses in business or in management. I think you want to try to give the person a good education in some relevant field such as engineering, which is a very good one but by no means the only one, and then give them the training in management afterwards.

Senator MacKenzie: Isn't the Harvard School of Business Administration doing something of this kind, Senator Cameron?

Senator Cameron: Yes.

Senator MacKenzie: I believe they offer places to a certain number of young men.

The Chairman: But they have a ceiling.

Senator MacKenzie: The best is the Sloane fellowship program where they select about 30 young men each year and it is one of the brightest group of young men you could come across. They select them for a year at MIT.

The Chairman: I suppose we could conclude this part of our discussion by saying we certainly need more research in the field of forecasting manpower requirements in Canada than we have now. I think we should suggest that as a result of this bit of knowledge the assistance which is given by the Government for the purpose of manpower training should become more flexible and more adjusted to this knowledge of market conditions as we go along.

Dr. Solandt: I would like to reiterate that I would urge the committee quite strongly that the message to get out of this sudden output of Ph.D.s from the universities is that at least we have faced the first step in upgrading the quality of our labour force, and now we are entering the second stage which is going to be difficult but which can and will be done to get these people integrated into industry. Unless we succeed in doing that effectively we are going to have to come back to the universities and say "The people you are training are not quite the people we want" but let us not cut off the flow at Ph.D. level just after we have got it going at enormous expenditure. This is what we are working for. Now is our opportunity.

The Chairman: I think we might be a little more systematic from now on and start with the report. I think the best way to do it is to put our questions more or less chapter by chapter, if it is agreeable to the members of the committee.

Hon. Senators: Agreed.

The Chairman: I suppose there is no problem about the summary.

Senator Grosart: Except that it is the whole report.

The Chairman: Do not be that nasty.

Senator Grosart: I did not mean it in that way.

Dr. Solandt: That is a compliment to the authors.

Senator Grosart: No, I did not mean it in that sense at all. The summary is really what is before us.

Senator MacKenzie: Could I ask one general question here, Mr. Chairman?

The Chairman: Yes.

Senator MacKenzie: This arises out of the whole report. How much co-operation is there between your council and the Economic Council?

Dr. Solandt: It is really quite close. We have Arthur Smith as a member of the Science Council. He has invited Dr. Gaudry and myself on one occasion to go and speak to the Economic Council—that is, have a session with them on mutual problems. I am sure this will be done again.

We have just recently achieved what I think is the most effective kind of collaboration. We raided each others staffs. Dr. David Henderson, a chemist, who is right here, left the Science Council staff to join the Economic Council staff, and we got Andrew Wilson from the Economic Council on to the Science Council.

Senator MacKenzie: Was it a good trade?

Dr. Solandt: It is too early to say. We lost a good player, but we also gained a good one. Curiously, each of them knows a tremendous amount about the problems of the Council to which they went, and they are still attending the staff meetings of the other Council, so here we have the beginning of a very effective inter-connection.

Senator MacKenzie: The reason why I ask this question, Mr. Chairman, is because one of the major concerns of the Science Council and the science community in Canada is the end result of their work in terms of the economic and social welfare of the country. The Economic Council is concerned, in the main, with economic development of the country and the problems related to it, and it would seem to me that one would more or less fit naturally into the other, and that the reverse is true.

Dr. Solandt: I think the interrelationships here are excellent. There is a continual interchange between the staffs, and continual discussion back and forth. Arthur Smith is on several of our committees and in addition, of course, we have excellent economic in-puts from other members. We have got Bob Bryce on the Council, and Simon Reisman from the Treasury Board. So, we have no lack of economic in-puts into the Science Council. Our problem is concerned with other social sciences.

The Chairman: But they are second-class citizens on your Council. They are only associate members. I wonder if this is not a source of frustration for them. I know that some of these people are not very easily frustrated, but that might inhibit their participation in your deliberations.

Dr. Solandt: If I might speak to that point I should like to say that other Government members who are full members want to be associate members. You see, this is a very real problem. Someone asked a question yesterday, which I did not get a chance to answer as to whether there were Government members on comparable bodies in other countries. The answer to that is: Generally, no. There are none in the United States on the President's Science Advisory Committee, for instance. In England the tradition is to have Government members on such a council as what are called assessors. I have never understood what that term means, but they are comparable to our associate members. They are persons who get all the papers, attend all the meetings, enter freely into all the discussion, but they do not have to sign a report that goes out.

The Chairman: That is the best position to be in.

Dr. Solandt: Well, several of the Government members on the Science Council have asked to be made associate members on the ground that the Science Council has already said things of which their ministers do not approve, and is quite likely to say things in the future that will be even further from the policies of some departments. It is difficult for a senior official of a department to appear to have signed a report which goes contrary to the wishes of his minister and his department.

So, the associate members, instead of being second-class members, are really a sort of super member, and the other Government members would like to join them.

Senator Cameron: Mr. Chairman, the first full paragraph on page 9 contains a statement which I think is at the heart of this whole study. It concerns the need for new machinery to implement some of the programs. It reads as follows:

> The rate of modern technological change is itself the source of an important social cost. Society and its institutions do not appear able to evolve rapidly enough to keep pace with technology—they respond to technological change too slowly to avoid the strains imposed on our civilization by new inventions.

And here I come to the important part:

> Too often organizational changes are made to redress the mistakes of the past instead of being designed to cope with the progress of the future. When a nation embarks on a course designed to promote scientific activity, it cannot expect to use yesterday's institutions to direct tomorrow's programs.

That is really what we are trying to find out here—the machinery that is needed to fill the gap.

You have just said in connection with the civil servants on your Council that they do not want to be in a position where they have to sign a document, and I think the discussions we have had so far emphasize that the gap is in getting the political action that is necessary. I am wondering if you had anything specific in mind that is not mentioned in your general recommendations. Your recommendations set out the kind of programs we could follow, but my question is: How do we translate these two lines, "When a nation embarks on a course designed to promote scientific activity, it cannot expect to use yesterday's institutions to direct tomorrow's programs."? What is the new institution or the new machinery we need?

Dr. Solandt: This was not directed just at the Government.

Senator Cameron: I know that.

Dr. Solandt: It is a general human problem. The universities have it acutely. I would say that the most serious stumbling block towards the evolution of universities "flexibility" towards the future, particularly in science and engineering, is in the departmental rigidities. I cite as an example the situation of a man wanting to get his Ph.D. in, say, studies of water pollution, and who finds he cannot. His Ph.D. has to be in physics or engineering, or one of the established disciplines. These disciplines fight vigorously for their prerogatives and for their right to control everything that goes on in the university. However, this is changing, and changing quite rapidly.

Another area in which we have desperate problems is that of urban renewal. We talk about urban renewal and the solving of the problems of the cities, but if someone came up today with an ideal plan that through some miracle contained everything you needed to do in the Ottawa area to make it an ideal place in which to live, it would probably take him ten years to get it through the mass of Government organization at different levels that is concerned with these urban problems. The resistance would not be to the idea, but to the change in the organizational structure in the institutions.

So, this is a very fundamental problem that pervades our whole society, right from the lowest levels of organization up through every part of it. I think that the federal Government has to try to solve this problem in its own affairs, just as every other level of human activity has to work on the problem at their level.

We see it particularly as a problem here in these major programs, that many of these are going to cut across the existing departmental lines which are highly institutionalized, similar to the departments in a university.

To my mind, the Space program is a good example, and you were asking why we had chosen Space for one of the earlier programs. As Jim Mullin reminded me last night, one of the major factors in choosing it was that although it may not be the most important problem in the world, it is one of the most urgent, because the Space activities of Canada are now in a stage of evolution when we can save them from fragmetnation if we act quickly and if we get a national Space program. Everyone agrees that we do not have—well I should not be quite so dogmatic—nearly everyone agrees that we do not have a well integrated national Space program, but each department concerned with Space says, "Well, we are doing our part, and it is just fine, so we do not really see a problem." But the bits do not add up to the kind of whole we ought to have.

We could get far more value for the money we are spending, and we could do more to solve some of our communications problems, some of our resource problems, and so on, and to build these skills at universities and in industry for the same money if we had an integrated program. Unfortunately, this will lead to demands for more money, but if they are sensible and this is the wise way of spending money, this is good. With the growth of this kind of thing you are going to use these highly skilled people.

The problem we discussed yesterday, of the sort of top organization, is another example of the problem. Then we are not so much up against institutional regidities, but the fact we have not yet seen an ideal or a particularly

attractive way of taking science into the top mechanism of Government.

I think probably the idea of a Minister without Portfolio, tried as an experiment for a year or two, might be the best immediate step. But this paragraph does not suggest we have any magic formula for solving the problems of human nature, but rather is pointing out the need for continually working at them.

Senator Grosart: Dr. Solandt, could we reasonably expect that this might be the subject of a special study commissioned by the Science Council? Many of us here seem to think this is the most important single question that has to be determined. Mr. Drury makes it a priority. He says: Which system—the American or European? You said yesterday, and obviously it would be so, a Canadian system, a system designed to meet our constitutional, parliamentary and other circumstances.

Is there any possibility the Council might devote some serious study to this particular problem and, in due course, come up with a positive recommendation?

The Chairman: I would accept that, provided I would become an associate member!

Senator Grosart: I am sure we would all like to see you in that capacity, Mr. Chairman—except if you were, you might have been less effective last night.

Senator Cameron: On this matter, assuming we came up with a recommendation that we should appoint an associate minister responsible for science, he could only be effective to the extent that he has a back-up organization behind him. I think we have to spell out here the kind of back-up organization he has to have. So far, I have not seen any crystalization of the ideas that might lead to the establishment of this kind of back-up organization, and I think we have to come up with them.

Dr. Solandt: Yes. In answer to your question, Senator Grosart, we have had this problem under discussion ever since the Science Council was formed, and it has been more active recently; but it is quite clear now, as a result of the discussions this morning and last night, that we must come up with a proposal, even if it is not obviously the finest proposal in the world, but the one we think is best for the present time, and then let other people discuss it and decide whether they have any better ideas. I think this discussion has made it quite clear—as we should have realized more clearly than we have—that that is a central point.

Senator Cameron: It might be directed not just to Government, but to the universities, because we all know how the entrenched establishment in the universities works, just as rigidly as it does in the Civil Service.

Senator MacKenzie: How are you going to change that?

The Chairman: By getting new Presidents!

Senator MacKenzie: Those who are now have nothing much to do with it.

Senator Grosart: I would like to raise a question arising out of Paragraph 4 of the Summary, which says:

> Throughout the report it is stressed that expenditures on science and technology must compete with many alternatives in the allocation of national resources.

This particular question is returned to, I think, at page 52, where we have a statement that I would hope you would say is perhaps an exaggeration of the viewpoint of the Council. The statement at page 52 reads:

> Canada should not fall into the trap of allocating this or that percentage of GNP to R and D and then dividing up this "budget for R and D" between the contenders for funds.

I am a bit concerned about the dismissal of the proposal that we should decide. Somebody should decide what overall proportion of R and D Canada should or must spend to maintain the kind of economic and social future for Canadians that we want.

The reason I raise this is this. Again, to quote Mr. Drury in this speech to the Tripartite Chemical Enginering Conference in Montreal on September 23—so it is a recent statement:

> I suppose the most fundamental question

—and he is talking about Science Policy—

> to be answered is what level of research effort the nation should support or conversely, to what extent we should rely on the import of technology to meet our domestic requirements.

In your First Report it seems to me you were taking quite an opposite view, because in your First Report, of June, 1967, at page 3,

I read this—and you are speaking of the comparative R&D expenditures in various OECD nations:

> Naturally, this group as a whole has a scale of expenditures and of productivity much diffierent from that in many countries that are not yet so highly industrialized. Even within the group there are wide differences in total resources, in population density, in defence and technological commitments, and in industrial, commercial and political structure.

And then—

> If these qualifications are kept in mind, it is possible to make meaningful comparisons.

Yet here is what seemed to me a slightly glib, glossing-over of the problem, as I read this statement, which now does not make sense. It appears at page 51.

> The Science Council first sought an indication of an appropriate level of investment in R & D for Canada by searching for some quantitative economic theory which would relate the level of investment in R & D to some corresponding rate of economic growth.

You say that you have not found this. In the next paragraph you say:

> ...the past record of any other country, given that country's goals, aspirations, problems and conditions—

almost exactly the same qualification as in June, 1957—

> should be of particular value as an indicator of what Canada should do in the future.

I should have read back. You are saying the opposite here.

In view of what I call a glib phrase, because I think that is what it is, that Canada should not fall into the trap, I am afraid this will be noted as a definitive position taken by the Science Council. I gathered from your remarks yesterday about the difficulty of writing section 9—and I can well understand it—that maybe you are not quite as sure that we can dismiss this component of the broad decision about our R & D position quite as cavalierly as it is done here. Is that correct?

Dr. Solandt: I think my difficulty here is one of trying to communicate the point of view. We obviously have not got it across adequately. You have not shaken me in my point of view or in the idea that this is a very good statement.

Let me try to make clear what I mean. I think we pobabrly have to begin by trying to distinguish between science policy, which is a policy for the use of science in all national activities, and a policy for science, which is a policy for how much money we will give to the support and growth of science in the nation. If you are talking about a policy for science, then I think you can decide how much you will spend on it and say, "Here is the pie. Cut it up as well as you can between the different claims of science." I think we will always have a small pie within the total which will tend to get cut up in this way. This will be particularly the case of small support of science within the universities. There is nothing logical about this. You could say, "We will spend $1 million, $10 million, $100 million, a billion on it." You make a judgment on how much is right.

Let us look at an example such as agriculture, which I think is a good one. We had better leave out constitutional issues in this discussion, and agriculture is a good example because it is a joint responsibility. The federal Department of Agriculture works out a program of support of agriculture which has all sorts of different elements in it. One of the elements will be research and development, and I think the decision on how much money is spent on research and development in agriculture should be a decision that is part of the broad general decision on what the nation is going to do about agriculture.

The Chairman: And research.

Senator Grosart: And the broad decision.

Dr. Solandt: They go to the point of saying, "Look, we have just got to do something about increasing the yield of substitutes for corn," or finding corn species which will grow further north in order to get more cattle feed and less human feed. Then they go to the pie department and are told, "Sorry, R and D is all sold this year. You can't do that."

Senator Grosart: With respect, this is exactly what you did in your ING recommendations. You said, "We have got to do it." I have never seen anything quite as explicit in a complete recommendation of anything as you gave to ING, with one exception, you made one qualification—"If we are going to progress from spending 1.3 per cent of GNP

on R and D to 2 per cent." Here you are doing this very thing. You are saying this recommendation is contingent on an overall decision on the amount Canada will spend on R and D. I respectfully suggest to you that much of the trouble in this area has arisen because at the moment nobody knows whether Canada has decided that this is a priority that can wait, that we do not have to push ahead from 1.3 per cent. Maybe we can wait a year. This could be the judgment. I do not know, but surely this has to be an element. My point is not that you do not consider it both ways, because if you are going to come up with, let us say, 2 per cent, obviously you will analyse the needs you mention.

In agriculture you will say what must be done here, there and elsewhere, then you add it up, and if it adds up to 4 per cent you say it has to be cut down. Surely there is some value in the Science Council, with its important overall responsibility, giving the Government some idea of the danger or advantage of not going ahead or of going ahead with the overall investment of our productivity, the re-investment in R and D. That is the point I am making. I am not saying there is no validity in the statement. I am saying that I object to the whole concept being brushed aside as cavalierly as it appears to be.

The Chairman: Before Dr. Solandt answers that I should like to add that, as Senator Grosart has just pointed out, in the process of budget making there are really two movements. When the budget for the ensuing year is being planned, the officials in the Department of Finance and Treasury Board first try to make a decision on what ought to be the total budget of the Government. I am sure you are aware of this process. These directives are then transmitted to the different departments. Then the departments look at their programs and make proposals. We must have the two processes working together at the same time. If you refuse to consider one of the processes in research, I think you distort the overall process of budget-making.

Senator Grosart: Before Dr. Solandt deals with that, I should like to get an answer to this, because our experience in this committee has been that your replies remove a lot of the doubts in our minds. I would like to point out further that in both your space program report and your water resources report you use this concept—you say there should be a 2 per cent annual increase.

The Chairman: Twenty per cent.

Senator Grosart: I am sorry. Twenty per cent annual increase. And you translate that into dollars. Surely you have to be relating this to some assumption of progress towards a total R and D goal.

Dr. Solandt: Let me take another example.

Senator Grosart: How many 20 per cents are you going to come up with?

Dr. Solandt: You are advocating that we should have a budget for economics, that we should tell the Bank of Canada, the Privy Council office, the Department of Finance, the Department of National Revenue and so on, that there is only so much money for economics in the Government and that they have to go and ask whether they can have another economist, because the decision has been taken that there is only so much economics that is good for the country. This is the parallel.

The Chairman: I do not think the parallel is well chosen. Secondly, I think that these things are done as a matter of course, where perhaps they should not be done. I think the parallel is not well chosen, for the good reason that the science budget is a peculiar case. Here is a segment of government expenditure which has long-term results and consequences.

Senator MacKenzie: Mr. Chairman, are you and Senator Grosart not assuming a centralization and concentration of scientific work, which may be desired, but as long as it is distributed among the departments and each department has a quota, it is going to be very difficult, then, to look at what the department thought their share of the budget should be for research.

The Chairman: This is one of the aspects of the present situation which is quite unsatisfactory to me.

Senator MacKenzie: It may be.

The Chairman: I am quite sure Senator Hays would have something to say about budget making in the field of research in agriculture.

Senator Grosart: This is exactly what the Government has done. It has done it with Manpower. It has said the situation is such that we cannot add to the staffs of public departments. This has been done right across all the departments. They say there is a limit. I am not suggesting that the Science Council should issue orders. What I come back to, Dr.

Solandt, is the advisory role of the Science Council in the input of science policy. I am merely suggesting that if the Science Council would say that there is a relationship—some people have contrary views—between the economic status, the standard of living in various countries—there is a relationship between that and the input of Government money into R and D. It may be anterior in some cases or it may be posterior in others. The evidence is that there is a relationship, of which you drew a beautiful picture here in your first report. You had these beautiful coloured charts showing these comparisons, and emphasizing the importance of them.

Dr. Solandt: I don't—have you got a copy?

Senator Grosart: Here it is. This is the beautiful coloured picture.

Dr. Solandt: But that has not anything to do with the productivity of the country. It just says that you conclude that because the U.S.A. is the top and is spending the most money it has the highest rate of economic growth. But actually Japan has a higher rate of economic growth than any of the nations above it.

Senator Grosart: But there is a relationship, or is this chart meaningless?

Dr. Solandt: No, there is not a relationship, and we say so. In the group of countries you see there, Japan has the highest rate of economic growth.

The Chairman: These comparisons, these so-called spurious correlations, are very misleading, because in my view it is silly to compare the current effort of a Government in the field of science and research, and the current GNP.

Dr. Solandt: I agree.

The Chairman: As I said before, the implications and consequences of research are really long-term, so when you compare current expenditure with current GNP you cannot get a correlation which would be valuable to science.

Dr. Solandt: It has been true for fifteen or twenty years. All I am saying is that we do not relate economic growth statistically to research and development expenditure. I think that in any of our reports we have always expressed the fact that there is a strong opinion and that everyone believes that there is a relationship, but we have not been able to state it quantitatively and that we have faith in the relationship.

Senator Grosart: Your actual comment, if I may make my point clear, is this—and I repeat what I said already:

> If these qualifications are kept in mind, it is possible to make meaningful comparisons.

If it is possible to make meaningful comparisons between input of federal money into R and D and something, what do you compare it with?

Dr. Solandt: If I might go back, there is a fundamental misunderstanding here between us, about the role of science. I come back to the economic argument, because you both immediately rejected that as being not sensible, because you know that economics is an integral part of the function of a bank, or the Department of Finance or the Department of Internal Revenue. What I am saying is that science is an integral part of the Department of Agriculture, Fisheries, Forestry, Energy, Mines and Resources, Industry, and you cannot separate it from these things and budget for it separately, any more than you can do it with economics.

Senator Grosart: I am not really suggesting that you budget for it. I am merely suggesting that there may be value in your advising the Government as to whether we are not putting enough comparatively or otherwise into R and D to assure the economic future of Canada in the next ten years.

Dr. Solandt: We said several times that we are not.

Senator Grosart: That is why I object to this other statement which seems to be put in opposition to that.

Dr. Solandt: Oh, no, it is not. I do not see that there is any opposition at all. The percentage GNP that you put in R and D is a sort of rough test to see whether you are paying enough or not enough. It is a rough test. If you say, as we say, that we have put 1.3 per cent, we have said that according to this rough test, that is not enough. So we do not say "let us put another .7 per cent in this year" What we say is: "Let us look at the whole of our society and see the places where we ought to be putting more in, where we can put it more effectively, and then we can look at the score a little later and if we say that the GNP has gone up to $3\frac{1}{2}\%$ we are doing quite well or we were at $1\frac{1}{2}\%$ and were

not doing well." My point is that you do not suddenly establish a big kitty of money and say "Run around boys and see if you can spend it."

Senator Grosart: That is not inherent in the complete picture of my suggestion. If you say to a cabinet, or to a person in an institution: "You are not doing enough, you are not spending enough money on X," the immediate and natural response is : "If it is not enough, how much?" Now, we are in this area of advice to a government, advice to laymen, and I am suggesting to you it is an important function of the Science Council to give the Government some guidance as to whether it is at the moment, putting in enough, and if not enough, what is the deficit?

Dr. Solandt: I still, with respect, do not feel it is the best approach. It may be the simplest, but I think we are not putting in enough and we say, now here are the areas in which we should put in more and let us get busy and put more in and put in the amount that is needed to achieve the things we want to do.

Senator Grosart: Perhaps we are saying the same thing, because eventually you have got to add up all your recommendations, but you want to put out a hundred reports and subjects to add it up and you are going to have the Government more confused than ever.

Dr. Solandt: I must agree that your point of view is not an uncommon one and we are just not communicating the idea properly. I hope I have gotten across the reason why we do not want to set a target as just a percentage of the gross national product. Science is an integral part of almost every action of the Government, and to say that every department has to spend 2 or 3 per cent of their budget—

Senator Grosart: I am not suggesting that. I am only speaking of guidance, over-all general guidance to the Government so they can make their decisions as in the ING case. Should we have abandoned this particular thing or should we have looked around to some place where may be we are spending enough? If the Science Council says you are not spending enough on R and D generally, then one could question the decision to make a cut in something already in that area, already recommended by the Science Council.

Dr. Solandt: We have said repeatedly we are not spending enough on R and D.

The Chairman: Before you came to that sentence, to which Senator Grosart has referred—we shall not fall into that kind of trap—did you consider the Belgium experience? They are trying to establish a kind of scientific budget.

Dr. Solandt: Yes, and so are the French.

The Chairman: The Belgians are more explicit in their exercise in this field.

Dr. Solandt: The means of increasing expenditure on science; it is probably pretty good, provided you have a good mechanism for deciding how you are going to spend it. I still think it is really just grossly oversimplifying the problem.

Senator MacKenzie: Mr. Chairman, I would like to refer to page 15 of the report, Goal 3: Education. The first paragraph states the elements of the goal, and I like the philosophy stated:

> —Opportunities for education of high quality, at all levels from elementary through to post-doctorate and including all forms of post-secondary training, should be readily available to all Canadians, to the limit of their individual abilities.

I have frequently made the same statement with two reservations, one subject to the competence financially and economic possibility of the country or the province being able to do this, and the other subject to the motivation of the individuals who are interested, particularly beyond high school.

This leads to the question I wanted to ask. There has been increasing pressure from the students in universities to be given free education, not only in terms of their fees but somewhat along the lines of the training and retraining in the manpower program of living subsidies, and so on and so forth.

I do not myself know whether this is socially desirable or feasible. I was wondering if Dr. Solandt would like to comment on this. The general objective and philosophy I like, but this particular area presents to me something of a problem. I have been one of those who have argued and felt that by and large higher education is something of a privilege and those who enjoy it should be expected to pay something for it in terms of their own efforts in getting it, or, if their parents are well to do, with the assistance of their parents, or, if necessary, through the borrowing of money perhaps without interest which can be

paid back when they get into the better paid echelons of society as a result of their advantages gained through university or post-secondary education.

Do you get what I am driving at, Dr. Solandt?

Dr. Solandt: Yes. I completely agree with you first comment. As I mentioned in reviewing the report we probably should have emphasized the general qualification that so many of these goals are mutually conflicting and exclusive that we obviously cannot give everybody a university education. We cannot afford it. So we have to limit this somewhere for financial reasons just as we have to limit almost every one of these goals. We have to get the mixture that we want of so much education and so much of other things.

On the second point of view I have divided thoughts. My own feeling is pretty nearly that of Senator MacKenzie's generation. Moreover, having had a father who was a Presbyterian minister, I feel that people should work for what they get.

The Chairman: That is a very old concept.

Dr. Solandt: I think that probably part of our trouble in the present generation is that we are beginning to have a transfer from the economics of scarcity to the economics of affluence, and the point of view that you have expressed is part of the economics of scarcity.

I think we are going to come to a time, not in Canada in my lifetime but possibly in the United States, when the attitude toward educating people will become such that a highly intelligent and competent person will be considered a national resource of great importance and it will be the job of the state to talk him into accepting the education he needs to make full use of his capabilities in the national interest. Some time in the future, in effect, the stage is going to seek out the scholar and educate him rather than the scholar going to seek out an education.

In my opinion it is the sort of transition between these two points of view that is causing some of our trouble nowadays. A good many students are beginning to realize that while an education is a privilege and an advantage to them it is also something that the state, the society, wants them to have and so they are beginning to say, "Well, if you want me to have an education, I am going to take it on my terms; not on yours."

Senator MacKenzie: Have you any worries about the problems that may arise through, in a sense, the creation of a state supported elite who get more out of the common pot than the rest of the population?

Dr. Solandt: I am sure it is going to cause real problems, but I do not think they will hit us in Canada, at least in my lifetime. What bothers me far more about the next 15 years is that people in Canada are beginning to get the feeling that we have already arrived in the post-industrial state and that it is not any longer necessary to work and that everything can be given to us. I do not think we in Canada are at that stage yet.

Senator MacKenzie: This is exactly what I am getting at.

Dr. Solandt: I do not think we are yet in that stage in Canada. I think we still have to teach people that they have to work hard if they are going to enjoy all of the things they want to have. In fact, we are seeing that right now.

The Chairman: If they work too hard they will not have time to enjoy it.

Dr. Solandt: That is right, there has to be a happy balance.

The Chairman: They have to have the benefit of their work.

Dr. Solandt: But we have not yet arrived at the stage in the development of Canada where we are in the so-called post-industrial state where very few people can produce everything that everybody else needs. We are still developing a large country. We still have frontiers and all the problems that go with them, and my worry is that we assume because we have some of the characteristics of the highly developed economy that we can behave like the United States.

Senator Cameron: Mr. Chairman, I would like to refer to section 3. I think this is at the basis of any progress we make, and I am sure you will agree with that. I want to make one distinction which probably comes from my own experience and prejudices. Senator MacKenzie has touched on a very critical area so far as our future policy and our philosophy of today are concerned. He is referring particularly to the undergraduate and the university post-graduate as well. But I say that because of the rate of technological change we must be as concerned in our society with the dropout who has Grade 7 as with the dropout who may have a PhD because unless he goes back to school he also becomes

obsolete. And here is where I think we consider the principle that we must provide opportunities for continuing education. We see this development in the establishment of community colleges and the kind of institution I run, and here is where we get into difficulty.

I have always maintained that the people taking courses as adults should pay the cost of the courses, because as a rule they are short-term courses; the people are on pay and for that reason I ask why should somebody else pay for their continuing education which should be in the main self-supporting. There are people in the adult education field who say that it should be free. I completely disagree with this. We should think in terms not only of basic education but also in terms of elementary, secondary, university and post-university education. We have to acknowledge, and I think most people do, the need for continuing education as an essential element of our total education program. That is why I say it is just as important for the PhD to go back to school as it is for the dropout from Grade 8. I don't think this is always recognized in the approach to the totality of our education program.

The Chairman: Do you have any comment on that, Dr. Solandt?

Dr. Solandt: No, except to say that I agree completely but with the same reservation that I put in before. When we get to the point where we regard skilled people as a resource, then we have the situation where you have to overhaul them as you overhaul plant. Then just as a company that is running a plant pays to have it overhauled, they will pay to have their staff overhauled from time to time—refurbished and brought up to date.

Senator Cameron: They are doing that today. All the people going to management schools are on payroll. The companies are recognizing this situation.

Dr. Solandt: If you accept the view that it should not be paid for by the Government where the benefit goes to industry, I entirely agree.

Senator Grosart: What section are we on?

The Chairman: Section 3. Any other questions before we move to section 5?

Senator MacKenzie: I would like to spend some more time on section 3 because I feel that this is in a sense the essence or the guts, if I may use that term, of this report and this problem. I would like to be sure we more or less agree as to the national goals as set out here, and what Dr. Solandt and the Science Council had in mind about achieving and realizing them through the support of their organization and the effective use of the scientific community in Canada.

Dr. Solandt: The council certainly has not gone into any detailed planning on how to achieve these goals other than to look at the contribution that science can make towards achieving them. It is obvious that none of these goals can be achieved by science alone. In some of them science can make a pretty important contribution, but for others it has a much smaller contribution to make. We have only looked at them from that point of view and with the hope that others will take a look at them also from other points of view with the aim that we may eventually have some agreed national goals towards which everyone works.

Senator MacKenzie: You made mention of urbanization and more or less organizational problems which confront solution to these problems which exist and which are increasing in practically every country today and which are the cause of a great deal of our difficulties. While we owe a great deal to science and technology in terms of improvement of our lives and in terms of coping with the strains of living, I don't think it is an exaggeration to say that the rapid change which science and technology has brought about and is bringing about and apparently will bring about at an even faster rate in the future is also creating problems for human beings that are going to be very serious. They are in fact very serious now. This is something to which I hope the Science Council will continue to give serious thought.

The Chairman: Or else.

Senator MacKenzie: You get the point I am trying to make.

Dr. Solandt: This is certainly a problem we have discussed frequently, and it is mentioned in here that the effects of the use of science are not necessarily all good. Sometimes they can be quite bad, and it is the responsibility of scientists to try to ensure that science is used where it can help, and where it cannot help that its use is curtailed or that it is used differently. But here again science is, as always, only another element in the situation.

Senator MacKenzie: I was not thinking so much about the practical results of science as much as whether anything can be done to assist human beings to adjust themselves to what science has done and is doing to them and their environment. You may say this is something, perhaps, a social scientist or humanist should tackle and try to answer, but I think it is a common problem, and as I say, I would hope that your council would continue to look at it from that broad point of view.

Dr. Solandt: I am sure we will, and we could do it much more effectively if we did it in partnership with social scientists.

The Chairman: We will try to make sure that this becomes possible.

Senator Cameron: I am looking at the last line here where it says "— the provision of better information services for education." Have you or any organization you know of made any special study of this with respect to bringing it up to date and the kind of machinery we should use and so on? Obviously the whole matter of information retrieval services is involved here, but is anyone making a special study on bringing this into the twentieth century too?

Dr. Solandt: I think this will be pretty adequately covered in the study we are doing now and information on which will be available in probably less than six months.

The Chairman: The Department of Immigration and Manpower has also embarked upon systematic studies of this, and we will hear more about this when they come before us. Are there any other questions before section 5?

Senator Hays: Mr. Chairman and Dr. Solandt, on page 14 you say in your "Goals":

> Provision of medical services of rising quality and efficiency.

How involved will the Council be when you speak of "efficiency"? I suppose that would also include inefficiency, and I will point out an example. For instance, in the province of Alberta we have about eight hospital beds per thousand people. California has about 3.8; Ontario, 5.4. Either we are abusing our beds system in Alberta, or we do not have enough here. I happened to be chairman of one of our hospital boards for a time, and I would estimate, from having confidential talks with the medical profession, our abuses were about 42 per cent. In other words, we had 42 people out of every hundred in hospital who should not have been there; and, at the same time, probably 10 per cent out of the hospitals who should have been in hospitals. This is certainly not efficient and it is very costly. Do you plan to do any studies in so far as this is concerned, on what are the proper ratios of doctors per thousand people, and as to how many trained people you have to have?

For instance, if you are going to deal with policemen you say, "If you want to stop all crime on our streets, you can do this by having one policeman to every three hundred people." But you say, "We have one to 500 or one to 700." Chicago has one to 500; Cincinnati one to 700. These crimes rise and fall all the time. You have so many barbers per thousand people. Do you plan on going into this field of efficiency as well?

Dr. Solandt: We would not plan to do this kind of study ourselves, but quite high on our list of priorities is to look into the problems of what we like to call the delivery of health services, and to make recommendations as to the kind of studies that need to be made and, hopefully, to make recommendations as to who should make them, because it is becoming increasingly obvious that our present health services mechanism is poorly conceived. It has just grown up out of the old, primitive doctor-patient relationship, and we have added services like nurses and so on, and it is pretty certain that if we start from way back and look at the matter from the point of view of fundamental programs, to see what a person needs in the way of health services and how you can devise a modern mechanism to deliver this service to him, not only a high-quality service but one at relatively low cost, I think, for instance, you will find that we need far fewer hospital beds than we did in the past. If you have motel-style accommodation, where a person who needs to be in hospital to have tests done could live there and walk across the street or walk through a tunnel to the hospital to get the tests done, that is one example of the kind of thing that can be done. This sort of exploration is beginning, and some is going on in Canada. It is becoming increasingly obvious this is one of the major areas in which we can produce savings in real cost to the community.

Health and education are the two areas where I think we can increase the efficiency of the operation without lowering the quality, and even improving it.

Senator Hays: Actually, there is sufficient money to do all the things we have to do in Canada, if we could stop the waste and misuse of funds. This is the great problem in Canada today, not only in educational centres but in the practice of medicine. They are all subject to abuses, and it seems to me there is plenty of room for somebody to do a study.

We can afford so much, to tackle this problem, but the misuse of funds is a great problem in Canada today. It is a lot easier to pay our taxes today than it was in the thirties. Regardless of what anyone says, people are better off today than they have ever been. If we could avoid this misuse by having more efficiency, I think there would have to be some terms of reference to say, "Well, these are adequate goals to reach."

Dr. Solandt: These two big areas of health services and education are ones where in the past there has been no commercial competition to sharpen up efficiency in prices, and the general feeling of the public has always been, "We want the highest quality, but don't bother us too much about the cost." But we are beginning to see that we are at the end of our resources. We are having to make choices, and these two big service areas, health and education, are ones where the possibility of improvement of efficiency is very great, because there has been no competitive force at work to improve the efficiency. So they are two areas we obviously must get started on quickly, and we have already discussed them and have begun planning how they might be tackled, but have not yet made any firm recommendations, except to include them in the list.

Senator Bourget: I have a question on the goals. No. 4 mentions, "Freedom, security and unity," and it says:

> Promotion of better understanding and co-operation between the different parts of Canada and between Canada and other nations of the world.

Dr. Solandt, how do you relate that to the role of the Science Council? Do you mean by this that science policy should be a source of public policy? Do you not think it is too explosive a field of operation for the Science Council to enter into, and that this should be left to the politicians, if I could use that expression? How would you consider that goal in relation to your role?

The Chairman: There is at least the beginning of an explanation on page 16.

Dr. Solandt: Well, these goals are not the goals of the Science Council. These are our idea of what the goals of the nation are. In an ideal world we would have gone to the Goals of the Nation Department and got the latest printed version of the national goals, and we would have written a report on how science could help achieve them; but since this is not an ideal world, we had to write our own goals.

Senator Grosart: You agree these are the goals?

Dr. Solandt: We say, "This is what we are using as national goals. What do you think of them?"

Senator Bourget: Oh, that is the meaning of it?

Dr. Solandt: Yes. I hope there will be a lot of discussion on them, with the idea of sharpening them and making clear what differences of view there are.

Senator Grosart: Section 4, page 20. I am not going to go back to my original argument on gross expenditures on research development, except perhaps to say, as I said to one of the co-authors of the report, that you are living a little dangerously here and getting into GERD. I point out that if you make it an agency it would become GERDA. But, to deal with the gross expenditure on R & D—

The Chairman: Do you want to join the club too?

Senator Grosart: I protested being at the end of the questioning yesterday, and perhaps I can repeat that protest now. I am not good at answering questions; that is why I ask so may.

Here, again, we have an historic projection of our expenditures on R & D, and you have indicated the three major areas—government, industry, and universities. Do you see it as a function of the Science Council to advise the Government as to what might be a reasonable apportionment of expenditure in respect of future science policy between these three main areas, both as to sources of funds and users of funds?

Dr. Solandt: Indirectly. I think it is the job of the Science Council to advise generally on the balance of effort between the different sectors of the scientific community, and then, having decided which things can best be done in which place, you see the distribution of expenditure changing.

Senator Grosart: You have made some recommendation for a major shift, generally into industry.

Dr. Solandt: Yes, but I do not think we should make the shift in the sense of saying you must spend X million dollars in industry. What we say is: "You might try to encourage an expenditure of more money by industry, and see how it goes." Perhaps we will get to the point of seeing that it is too much, but I do not think I shall live to see it.

Senator Grosart: You would not go so far as to suggest broad percentages for, say—would you make a projection for a few years, or a decade, ahead of the figures contained in Table 2 on pae 21? Those figures are 36, 44, 19, and 11 as current expenditures by sector of performance of Government, Industry, Higher Education, and Private Non-Profit respectively.

Dr. Solandt: I would be very doubtful if we can. What I would rather do is say that we should pursue policies of stimulation for research and development, and outline those policies in some detail, including the major programs that we have put in here. We would hope that the result of these would be that the GERD would reach these levels at these times, and the different levels between the sectors would follow.

Senator Grosart: Is there not some danger, Dr. Solandt, if you are not more specific, that you are going to have the same thing happen that you have complained of? Somewhere there was a policy—whether it was expressed or just automatic—for this series of spot decisions as to what we spent. You say there should be a change from the situation that has developed as a result of that series of *ad hoc* decisions, which has put us in the position that today too much of the effort is being made by government and not enough by the industrial research sector. Is there not a danger, if you are not fairly specific and if you make this general statement that you think there should be more going into industrial research, that we will wind up in a few years with government trying to follow your advice with imbalanced action. Is there not some value in your accepting the responsibility of giving some much more specific advice to government?

Dr. Solandt: I agree, but the specific advice must be for programs. It must not be advice to the effect that you must spend X million, but that you must achieve a certain objective.

In this respect I might just observe that the nation that is pointed to with envy by everyone is the United States. It has never budgeted for a percentage of G.N.P. They never even talk about it. I do not think they ever even thought about what percentage of G.N.P. they were spending on R and D until OECD added it up and showed it to them. They have always thought in terms of programs. I have heard many people say that it is just impossible to change the rate of expenditure on R and D rapidly. Well, look at what has happened in the United States. As I remember the figures—and this is pretty rough—they went from spending 3 per cent of the total federal budget on R and D up to 10 per cent in a very few years.

Senator MacKenzie: On this point may I ask how much of that is due to the international situation, or the involvement of the United States in international affairs at the present time?

Dr. Solandt: Let me say that this is because they decided to put a man on the moon and to have an intercontinental ballistic missile program. Those were programs they decided upon, and nobody asked: "Is this going to result in our spending 2, 3, or 4 per cent of G.N.P. on R and D?" They said: "These are the things we want to do." They then went ahead and did them, and this has raised their expenditure to a very high level. But, they did not plan to spend so much money.

Senator Grosart: But they have a different system from ours. The authority there to go ahead comes from a subcommittee on appropriations, either of the House of Representatives or the Senate, or Congress as a whole. We do not have this. I doubt that you meant to say that they went ahead with these programs not knowing what percentage of G.N.P. they were going to spend. I am sure that they did. They may have known it only in terms of dollars, but if you read the reports of those subcommittees you will find that they are continually saying to themselves: "Can we afford this?" or: "We are spending this vast amount of money this year out of a budget of so much", which is the same thing.

Dr. Solandt: But, they are not saying: "We have allocated 3 per cent of G.N.P. to research and development. Is this going to push it over that?" They say: "We have $X million to spend this year. Is this the program we are going to spend it on?".

Let us take a specific example. I think we are all agreed that Canada ought to do more research and development and innovation on urban problems. Rather than saying: "Let us get up to 2 per cent of G.N.P. next year", why do we not say: "Let us start a really big program in respect of some of our critical urban problems next year?" That will push the expenditure up, but let us make it an objective, and not make the objective the spending of 2 per cent of G.N.P.

Senator Grosart: I do not think we are very far apart.

Dr. Solandt: No, we are not, really.

Senator Grosart: You tend to use certain terminology and say that we should not spend such a percentage. I am not suggesting we should. I am speaking of advice—of presenting conceptual pictures to the Government so that it has some broad guide-lines. I am not saying: "You must spend this on this". What I am saying is that there would be value in your saying: "This looks like a very reasonable balance of expenditures on R and D in respect to GNP, and in respect to the various sectors of performance in R and D." That is all I am saying, and I do not think we are far apart.

Senator MacKenzie: May I ask just one other related question? It has come up in respect of external aid, and how we compare with other countries. It is difficult to get comparable figures because of the different ways in which money is spent and credited. With respect to our own case here I have in mind the fact that the United States and Britain spend far more on military affairs, and research, so-called, in military affairs, than we do. This inevitably pushes up their expenditures, so called, on research, and all I am suggesting is that we must look very carefully at what goes into the statistics presented for comparable purposes before we accept them.

Dr. Solandt: Yes, there is no question but that a great part of the U.S. expenditure is on space and military research. I do not have the figures at my fingertips, but they are easily available. This has to be qualified a little because undoubtedly a great deal of the competence of U.S. industry in world markets and their availability to compete effectively in world markets arises out of the work they have done.

Senator MacKenzie: I agree.

Dr. Solandt: I remember speaking not long ago to the head of a big corporation in the U.S. who said, "We have a $100 million program of research and development for the government, and we have a $3 million program of our own company money which is aimed largely at applying the results of the government program to our own commercial products", so the expenditure for defence and space is not entirely unrelated.

Senator MacKenzie: They are byproducts.

Dr. Solandt: There are cross-connections between the two.

Senator Grosart: Is it not the American experience that the spin-off benefits are increasing percentagewise each year?

Dr. Solandt: I do not know of any real solid evidence to support that, but I think there is certainly a general feeling that way.

Dr. Grosart: I recall an article or a study asserting that.

Dr. Solandt: Another thing we must remember when talking about American space and defence work is that it really supports only a very small part of their total industry. I remember hearing Herb Holloman, when he was Assistant Secretary of Commerce, talking about this and pointing out that many of the major industries in the United States, such as the steel and chemical industries, with the sole exception of explosives, get virtually no government support at all. Some of them are very good and some of them are quite bad. For instance, the Canadian steel industry compares very favourably with the U.S. steel industry yet it is wholly owned and controlled in Canada and, like the U.S. depends very largely on technology imported from Europe, but it has been much more aggressive and competent in importing this technology. There again, let us not assume that defence and space expenditure pervades the entire industrial economy. It affects only a rather limited sector of it. It is the spectacular sector that we see and hear about.

The Chairman: But perhaps those sectors which will expand more rapidly in the future.

Dr. Solandt: Yes.

The Chairman: I have one brief question on figure 1 on page 20. It is related to the direct federal support for university R and D. Do you imply by this that there was no direct

federal support for this purpose prior to 1959?

Dr. Solandt: No, it is less than $10 million. The graph is chopped off at $10 million. It is a log scale and if you went down to zero, zero would be way off the bottom of the page.

The Chairman: Are there any other questions?

Senator Grosart: Are you going to section 5?

The Chairman: It is quite clear that we will not finish this discussion today, because I at least have many questions from section 5 on. I am sure other members of the committee will also have many questions. We come back to what we were discussing yesterday, your availability, Dr. Solandt, in the next few weeks.

Dr. Solandt: Would you like to try to set a date now, or could we discuss it later?

The Chairman: If the members of the committee would leave this in my hands, the staff and I could discuss this with Dr. Solandt so as to arrange a satisfactory date. Is that agreeable?

Hon. Senators: Agreed.

The Chairman: We will then go on from section 5. Thank you very much again, Dr. Solandt.

Senator Grosart: Mr. Chairman, I think we should express our thanks to Dr. Solandt for all the time he and his associates have given us. It is unusual that we should keep one witness for as long as we have.

Senator MacKenzie: It is a measure of his importance.

Senator Grosard: We have enjoyed it and we will welcome him back, and try to be nicer!

The committee adjourned.

APPENDIX 8

BRIEF

TO THE

SPECIAL COMMITTEE ON SCIENCE POLICY

OF THE

SENATE OF CANADA

Submitted by the

Science Council of Canada

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Membership and Terms of Reference

(1) The Science Council of Canada Act, which received Royal Assent on May 12th 1966 created a Council, to consist of "not more than

(a) twenty-five members chosen from among persons having a specialized interest in science and technology;

and

(b) four associate members chosen from among officers or employees of Her Majesty employed in departments or agencies of the Government of Canada.[1]"

whose task was to be

"to assess in comprehensive manner Canada's scientific and technological resources, requirements and potentialities and to make recommendations thereon to the Minister; and in particular it shall be the duty of the Council to give consideration to, and make reports and recommendations to the Minister on,

(a) the adequacy of the scientific and technological research and development being carried on in Canada;

(b) the priorities that should be assigned in Canada to specific areas of scientific and technological research;

(c) the effective development and utilization of scientific and technological manpower in Canada;

(d) long term planning for scientific and technological research and development in Canada;

(e) the factors involved in Canada's participation in international scientific or technological affairs;

(f) the responsibilities of departments and agencies of the Government of Canada, in relation to those of universities, private companies and other organizations, in furthering science and technology in Canada;

(g) the statistical and other information on scientific and technological research and development that should be obtained in order to provide a proper basis for the formulation of government policy in relation to science and technology in Canada; and

(h) the best means of developing and maintaining co-operation and the exchange of information between the Council and other public or private organizations concerned with the scientific, technological, economic or social aspects of life in Canada.[2]"

At present the Science Council reports directly to the Prime Minister.

(2) The original twenty-five members and four associate members are listed in the First Annual Report of the Science Council, which is attached as Appendix I. The present membership of the Science Council, as of September 1968 is as follows

Dr. O.M. Solandt, Chairman; Chancellor, University of Toronto

Dr. Roger Gaudry, Vice-Chairman; Rector, University of Montreal

Dean W.M. Armstrong, Faculty of Applied Sciences, U.B.C

Dr. J.M.R. Beveridge, President, Acadia University

Dr. G. Malcolm Brown, Chairman, Medical Research Council

Prof. P. Dansereau, Department of Environmental Studies, University of Montreal

Dr. William H. Gauvin, Manager, Noranda Research Centre

Dr. P.A. Giguère, Professor of Chemistry, Laval University

Mr. J.L. Gray, President, Atomic Energy of Canada

Dr. J.M. Harrison, Assistant Deputy Minister, Department of Energy, Mines and Resources

Mr. J.D. Houlding, President, RCA Victor Ltd.

Mr. Leonard Hynes, President, Canadian Industries Limited

Dr. Josef Kates, Management Consultant

Dr. Leon Katz, Director, Accelerator Laboratory, University of Saskatchewan

Mr. Roger Larose, Special Consultant to the Rector, University of Montreal and President, CIBA Co. Ltd.

Dr. F.C. MacIntosh, Drake Professor of Physiology, McGill University

Dr. A.W.H. Needler, Deputy Minister, Department of Fisheries

Dr. G.N. Patterson, Director, Institute for Aerospace Studies, University of Toronto

Dr. H.E. Petch, Vice-Principal Academic, University of Waterloo

Mr. P.R. Sandwell, President, Sandwell and Company Limited

[1] Science Council of Canada Act, Clause 3—see or example Appendix I, Science Council of Canada, 'irst Annual Report, p. 24.

[2] Science Council of Canada Act, Clause 11.

Dr. W.G. Schneider, President, National Research Council

Dean L.H. Shebeski, Faculty of Agriculture and Home Economics, University of Manitoba

Dr. R.J. Uffen, Chairman, Defence Research Board

Mr. D. Wermenlinger, Manager of Engineering, Churchill Falls (Labrador) Corp. Ltd.

Dr. J.D. Wood, Vice-President, ATCO Industries Limited

Associate Members

Mr. R.B. Bryce, Deputy Minister, Department of Finance

Mr. S.S. Reisman, Secretary, Treasury Board

Dr. A.J.R. Smith, Chairman, Economic Council of Canada

Dr. J.R Weir, Director, Science Secretariat, Privy Council Office

(3) The Act empowers the Council, in carrying out its duties, to "utilize the services of such officers and employees of Her Majesty employed in Departments of the Government of Canada as the Governor-in-Council may designate"[3]. To date, the full-time staff of the Council have been provided by the Science Secretariat of the Privy Council Office, an arrangement based on a recommendation of the Glassco Commission[4] and proposed in a report to the Prime Minister by Dr. C.J. Mackenzie in early 1964[5].

(4) The Science Council met for the first time in Ottawa on July 5, 1966; since that time it has met in Ottawa, Montreal, Halifax, Quebec City, Toronto and Winnipeg. The meeting in September 1968 was the fourteenth.

Operating Methods

(5) During its twenty-six months of operation, the Science Council has evolved a system of operation which permits it to have an area of interest studied and to formulate appropriate recommendations for policy. The system adopted involves the delegation of specific authority to two distinct groups—an ad hoc *Science Council Committee* and a *Special Study Group.*

(a) *Science Council Committees*

(6) It is the responsibility of each Committee of the Science Council—to oversee the study of an area of interest to the Council. (e.g. the Earth Sciences, Agricultural Research, etc.;. This includes the responsibility for authorizing the creation of a Special Study Group, for agreeing to the membership of the Study Group and for determining detailed terms of reference for the Study Group—to frame policy recommendations on the area of concern, for discussion by the Science Council, based on the report prepared by the Special Study Group and on any other relevant material—to draft and oversee publication of a *Report of the Science Council*, containing all recommendations agreed to by the Council.

(7) Members of Science Council Committees are drawn from within and outside the Council. Chairmen of the Committees are normally, but not always, members of the Council. Membership lists for all currently-operating Committees are attached as Appendix II. Members are selected for their specialized knowledge of the field under study and an attempt is made to have all interested sectors of the economy represented. They are appointed by the Science Council.

(b) *Special Study Groups*

(8) Special Study Groups are established, with the assistance of the Science Secretariat, and given responsiblity for—conducting an investigation of the present state and future needs of an area of interest to the Science Council, within the scope of terms of reference agreed to by the appropriate Science Council Committee—presenting a written report on their investigation for transmittal to the appropriate Science Council Committee and thence to the Science Council (In general these reports are published as *Science Secretariat Special Studies*)—providing such assistance and advice as is requested by the Science Council Committee.

(9) Members of the Special Study Groups are active scientists from the field under study and are retained under contract or by secondment for the duration of the study, by the Science Secretariat. Each Special Study Group is assisted by a staff member of the Science Secretariat who is appointed as Project Officer for the Study.

(10) Table I indicates all of the Council Committees and Special Study Groups which have operated to date. For each are listed

—the subject studied
—the Chairman
—the date of reporting, whether actual or expected.

In two cases, indicated by asterisks, the Chairman of Science Council Committees

[3] Science Council of Canada Act, Clause 14.

[4] Royal Commission on Government Organization, Vol. 4, p. 224 (190).

[5] Report to the Prime Minister on Government Science, submitted by Dr. C. J. Mackenzie, January 1964.

TABLE I

COMMITTEES OF SCIENCE COUNCIL AND THEIR STUDY GROUPS

Topic	Science Council Committee		Special Study Group	
	Chairman	Date of Reporting (Actual or Expected)	Study Group Lesder	Date of Reporting (Actual or Expected)
Agricultural Research	L. H. Shebeski	Spring 1969	B. N. Smallman	Spring 1969
Aeronautical Research	J. J. Green*	Spring 1969	No Study Group	
Basic Biology	F. C. MacIntosh	Spring/Summer 1969	K. J. Fisher	Spring 1969
Earth Sciences	W. H. Gauvin	Winter 1969	R. A. Blais	Fall 1969
Engineering Research	P. R. Sandwell	Early 1969	G. Sarault	December 1968
Physics and Chemistry	H. E. Petch	Spring 1969	D. C. Rose—(a) Physics	June 1967**
			A. E. R. Westman—(b) Chemistry	Fall 1968
Science Policy	O. M. Solandt	October 1968**	No Study Group	
Scientific and Technical Information	L. Katz	Summer 1969	J. P. I. Tyas	December 1968
Support of Research in the Universities***	R. Gaudry	Spring 1969	J. B. Macdonald	December 1968
Water Resources Research	J. T. Wilson*	September 1968**	J. P. Bruce	September 1968**
Review of ING Proposal	J. D. Houlding	March 1967**	No Study Group	
Upper Atmosphere and Space	Discussed by full Council; no committee formed	July 1967**	J. H. Chapman	February 1967**
Psychology	No committee formed	N/A	M. H. Appley	September 1967**
Transportation	No committee formed	N/A	C. B. Lewis	Fall 1968

*Not a member of Science Council.
**Reports published (see list of publications).
***Jointly sponsored by Science Council and Canada Council.

were not members of the Council. No study group leaders are Council members.

(11) In the early days of the Council's existence this system was not always followed in detail, but it does represent the most common pattern now used.

Program of Studies

(12) At the first meeting of the Science Council, in July 1966, the Science Secretariat reported that four studies were under way, covering

—Upper Atmosphere and Space Programs
—Physics in Canada
—Psychology in Canada
—Agricultural Research.

At this same meeting the Council discussed proposals made by various bodies for studies of

—Engineering Research
—Water Resources Research
—Transportation Research

and agreed that such studies should be carried out. The Science Secretariat subsequently established study groups for each of these areas.

(13) At the second meeting of the Council, in October 1966, a request was received from the then Minister of Mines and Technical Surveys for a review by the Science Council of Atomic Energy of Canada Limited's proposal to construct an Intense Neutron Generator (ING). The Council organized a Committee to conduct this review and also agreed to conduct studies on

—R & D in Chemistry in Canada
—The Support of Research in the Universities.

(14) At the third meeting of the Council, in November 1966, it was agreed that a study would be undertaken of the field of

—Basic Biology

(15) While the Science Council had encouraged the initiation of a series of "inventory studies" of activities in the various scientific disciplines, it was also conscious of the fact that one of its principal objectives was the formulation of an overall science policy which could be commended to the Federal Government. The problems of articulating such a science policy were actively discussed by the staff for some time before the first formal discussion on this topic by the full Council in June 1967. These discussions have continued throughout the meetings that have followed and the first product of this work is Science Council Report No. 4 "Towards a National Science Policy for Canada" which is attached to this brief as Appendix III.

(16) At the ninth meeting of the Council, in November 1967, it was formally reported that a study of Scientific and Technical Information, being jointly financed during its first year of operation by the Department of Industry and the Science Secretariat, was under way. The Science Council subsequently agreed to discuss the report of this study group, once it became available.

(17) Two studies, on

—the Earth Sciences
—Aeronautical R&D

were set in motion at the twelfth meeting of the Council in May 1968.

(18) The first round of studies indicated in Table I and nearing a completion with all but one of them scheduled to end by the Spring of 1969. Detailed planning of the next round of activities is already under way and will be discussed at length at the Fifteenth Meeting of the Science Council in November. The first Policy Report (Science Council Report No. 4) commits the Council to establishing task forces to be responsible for the preparation of specific recommendations to bring about the implementation of four new major programs. The Council will also be considering the need for any further inventory studies, to complete the picture of Canadian science which these disciplinary studies seek to provide.

(19) In addition to these studies, the Council will address itself to concentrated study of some of the many fundamental problems of science policy. Problems which must one day be tackled include the relationship of R & D to economic growth, the interaction of scientific activities in the principal sectors of the economy, means of stimulating industrial R & D, etc.

Funding

(20) Tables 2 and 3 indicate the expenditures to date on Science Council activities. Most of the funds expanded have come from two sources—

(a) the vote of funds to the Science Council

(b) the allotment within the Privy Council Office budget for the operation of the Science Secretariat.

The major exceptions to this general pattern are the two cases, indicated in Table 3, in which other organizations have co-sponsored parts of major studies.

TABLE 2

Expenditures on Science Council Activities

	1966-67	1967-68	1968-69
(a) Science Secretariat Operating Expenses	274,460	375,710	191,080
(b) Science Council Staff Costs (Estimated as 75% of (a))	205,850	281,780	183,310
(c) Science Council Operating Costs	68,980	122,310	60,420
(d) Direct Cost of Studies	176,750	556,360	265,920
Estimated Total Cost of Science Science Council Activities ((b)+(c)+(d))	451,580	960,450	509,650

* To August 31, 1968 only.

(21) Since the creation of the Science Council, staff work for the Council has been performed by members of the Science Secretariat in the Privy Council Office. Some members of the Science Secretariat staff have devoted their full-time efforts to support of the Science Council, some have spent part-time on Council business while others have been fully occupied by Secretariat duties which did not involve the Science Council. It is estimated that about 75% of the total efforts of the Secretariat were in support of the Science Council, principally in administering the program of studies discussed earlier, and therefore it is judged appropriate that 75% of the operating costs of the Secretariat should be attributed to Science Council activities, in order that a realistic estimate be presented of the total annual cost of running the Science Council. Item (b) of Table 2 records the cost of the staff assistance provided by the Science Secretariat. These funds were provided from the Secretariat allotment within the budget of the Privy Council Office.

TABLE 3

Direct Costs of Studies for Science Council

	1966-67	1967-68	1968-69*
Agriculture	71,770	105,920	32,780
Basic Biology	5,310	73,170	69,150
Upper Atmosphere and Space	22,900	4,100	—
Water Resources Research	2,850	70,510	10,160
Chemistry	45,000	35,000	2,190
Support of Research in the Universities	240	85,390	59,720**
Assessment of Intense Neutron Generator Proposal	1,880	10,920	—
Physics	20,000	5,220	—
Scientific and Technical Information	—	104,950***	62,510
Earth Sciences	—	—	11,720
Engineering Research	—	32,800	7,890
Psychology	6,800	14,230	—
Transportation	—	14,090	9,790

* To August 31, 1968 only

** Science Council paid $16,840 of this amount; the remainder was paid by Canada Council

*** Science Secretariat paid $57,680 of this amount; the remainder was paid by Department of Industry.

(22) The Science Council Operating Expenses, funded entirely from the Science Council Vote, include the cost of conducting meetings of the Council and its Committees, travel expenses for members, remuneration to the Chairman, costs of publishing the Annual Report of the Science Council, etc.

(23) The costs for the various studies were charged in part to the Science Council vote and in part to the Science Secretariat budget for studies (except where otherwise noted). These costs include fees to consultants, travel expenses, salaries for research assistants, clerical and stenographic help, data acquisition and processing costs, publication costs where applicable, etc.

(24) To arrive at accurate total costs for individual studies it would be necessary to add to the totals quoted in Table 3 an appropriate share of the total quoted in Item (b) of Table 2, to take account of the cost of administering the studies.

(25) Tables 2 and 3 represent the best estimates of the cost of operating the Science Council and its studies, but it is recognized that some costs still have not been included. A number of Departments of the Federal Government have permitted members of their staffs to participate in the Council's programs as members of study groups without charge to the Science Council. The Council wishes to gratefully acknowledge this valuable assistance.

Views on Science Policy

(26) A principal objective of the Science Council is the preparation of recommendations to the federal government on the establishment of a science policy for Canada. The first major step in this direction was the recent publication of

> "Science Council of Canada Report No. 4 Towards a National Science Policy for Canada",

which is attached as Appendix III to this brief.

(27) This report attempts to lay the basis of a sound policy for the use of science and technology in the quest to realize Canada's national goals. The fundamental principles laid out in the report are

(1) Canada must specialize in fields of science and technology which are important to Canada instead of attempting to spread her available resources thinly across all of the frontiers of science.

(2) The bulk of new resources made available to science should be used to used to solve problems of economic or social importance.

(3) The available resources of funds and manpower should be allocated to the attempts to solve problems influenced by Canadian conditions and not to duplicating activities being supported in other developed nations.

(4) The centre of gravity of Canada's research effort should shift from government laboratories to industry and the universities.

(5) The future emphasis of Canada's science should be placed more heavily on development and innovation rather than on research which is not carried through to implementation and use.

(28) The text of Science Council Report No. 4 should be taken as the central part of this brief.

Relationship with Federal Departments and Agencies, Industry and the Universities

(29) The membership of the Science Council is approximately evenly divided among representatives of government, industry and the universities and in establishing committees and study groups the Council seeks to maintain representation of all interested sectors of the economy.

(30) Table 3 shows the distribution of members of Council and of Council Committees, as well as study group leaders among the principal sectors.

TABLE 4—Distribution of Members Among Sectors

	Federal Public Service	Provincial Public Service	Industry	University
Science Council ..	10*	0	9	10
Council Committees .	**16	2	24	27
Study Group Leaders .	5	1	1	5

* Includes four Associate Members

** Individuals serving on more than one committee are counted once for each committee on which they serve.

(31) As indicated in paragraph (3), the Council is permitted to utilize the services of officers of any department of Government. To

date staff assistance has been obtained from the Science Secretariat, the Departments of Industry, Energy, Mines and Resources, and Indian Affairs and Northern Development and from the National Research Council. The Council looks forward to continued close relationships with all departments of government.

Publications

The following publications have been issued by the Science Council.

Science Council of Canada, First Annual Report, (June 1967), Second Annual Report, (June 1968)

Science Council of Canada, Report No. 1, A Space Program for Canada (July 1967)

Report No. 2, The Proposal for an Intense Neutron Generator, Initial Assessment and Recommendations (Dec. 1967)

Report No. 3, A Major Program of Water Resources Research in Canada (Sept. 1968)

Report No. 4, Towards a National Science Policy for Canada (Oct. 1968)

In addition to these documents the Science Secretariat has published a series of reports prepared for consideration by the Science Council. These are

Science Secretariat, Special Study No. 1—Upper Atmosphere and Space Programs in Canada (Feb. 1967)

Science Secretariat, Special Study No. 2—Physics in Canada—Survey and Outlook (May 1967)

Science Secretariat, Special Study No. 3—Psychology in Canada (Sept. 1967)

Science Secretariat, Special Study No. 4—The Proposal for an Intense Neutron Generator—Scientific and Economic Evaluation (December 1967)

Science Secretariat, Special Study No. 5—Water Resources Research in Canada (July 1968)

Science Secretariat, Special Study No. 6—Background Studies on Science Policy: Projections of R & D, Manpower and Expenditure (in press)

ANNEX I

MEMBERSHIP LISTS FOR SCIENCE COUNCIL COMMITTEES

In the following lists, members of the Science Council are referred to by name only. Non-Science Council members serving on these Committees are listed by name and title.

Science Council Committee on Support of Research in the Universities

Chairman: Dr. Roger Gaudry

Members:

Dean W. M. Armstrong

Dr. Walter H. Johns,
President,
University of Alberta,
Edmonton, Alberta.

Dr. G. Malcolm Brown.

Professor J. E. Hodgetts,
Principal, Victoria College,
University of Toronto,
Toronto, Ontario.

Professor Malcolm M. Ross,
Department of English,
University of Toronto,
Toronto, Ontario.

Professor A. E. Safarian,
Department of Political Economy,
University of Toronto,
Toronto, Ontario.

Dr. H. E. Petch

Dr. Francis Leddy,
President,
University of Windsor,
Windsor, Ontario.

Professor Jacques Brazeau,
Department of Sociology,
University of Montreal,
Montreal, Que.

Professor William Mackey,
Director,
International Research Centre
for Bilingualism,
Department of Agriculture,
Laval University,
Quebec City, Que.

Dr. L. H. Cragg,
President,
Mount Allison University,
Sackville, N.B.

Dr. W. G. Schneider,
President,
National Research Council

Mr. G. G. E. Steele,
Under-Secretary of State,
Secretary of State Department,
Ottawa, Ontario.

Dr. J. R. Weir

Dr. O. M. Solandt,
(Ex Officio)

Science Council Committee on Engineering Research

Chairman: Mr. P. R. Sandwell

Members:

Dean W. M. Armstrong
Dr. William H. Gauvin
Dr. G. N. Patterson
Dr. H. E. Petch
Dr E. R. Rowzee

Ex Officio:
Dr. O. M. Solandt
Dr. Roger Gaudry

Science Council Committee on Physics and Chemistry in Canada

Chairman: Dr. H. E. Petch

Members:

Dean W. M. Armstrong
Dr. W. H. Gauvin
Dr. Leon Katz
Mr. Roger Larose
Dr. G. N. Patterson
Dr. R. J. Uffen

Science Council Committee on
Agricultural Research
Chairman: Dean L. H. Shebeski

Dean J. W. Ker

Mr. A. D. Turnbull

Dr. G. F. Clarke,
Vice-President,
Canada Packers Limited,
2200 St. Clair Avenue West,
Toronto 9, Ontario.

Mr. David Kirk,
Secretary,
Canadian Federation of Agriculture,
111 Sparks Street,
Ottawa 4, Ontario.

Mr. Charles Gibbings,
President,
Saskatchewan Wheat Pool,
Regina, Sask.

Dr. Bertrand Forest,
Director,
Quebec Agricultural Research Council,
Quebec City, Que.

Science Council Committee on
Scientific and Technical Information
Chairman: Dr. Leon Katz

Members:

Mr. J. D. Houlding
Dr. W. H. Gauvin
Dr. G. M. Brown
Dr. J. D. Wood
Dr. J. M. Kennedy
Director,
Department of Computer Science,
University of British Columbia,
Vancuver 8, B. C.

Mr. K. J. Radford,
Director,
Central Data Processing Bureau,
Ottawa 4, Ontario.

Mr. L. F. MacRae,
Chief Librarian,
Guelph University,
Guelph, Ontario.

Science Council Committee
on Earth Sciences
Chairman: Dr. William H. Gauvin

Members:

Dr. Harrison

Dr. R. J. Uffen

Dr. R. F. Legget,
Director,
Division of Building Research,
National Research Council,
Ottawa, Ontario.

Dr. J. T. Wilson, Principal,
Erindale College,
University of Toronto,
Toronto, Ontario.

Dr. H. Gunning,
Consulting Geologist,
125/4800 Arbutus St.,
Vancuver 9, B.C.

Dr. R. Folinsbee, Chairman,
Department of Geology,
University of Alberta,
Edmonton.

Mr. R. Geren,
Box 91,
Oromocto, N.B.

Mr. F. Zurbrigg,
Vice-President,
International Nickel Co.,
Box 44, Toronto Dominion Centre,
Toronto 1.

Dr. G. C. Monture,
Special Consultant,
Resources Engineering of Canada Ltd.,
56 Sparks Street, Room 610,
Ottawa 4, Ontario.

Dr. D. H. McDonald,
President,
H. G. Acres Co.,
Niagara Falls, Ontario.

Dr. G. W. Govier,
Chairman,
Oil and Gas Conservation
Board of Alberta,
603-6th Avenue S.W.,
Calgary, Alberta.

Science Council Committee on Aeronautical Research

Chairman: DR. J. J. GREEN
Vice-President, Research and Development,
Lytton Systems,
25 City View Drive,
Rexdale, Ontario.

Members:

Mr. J. T. Dyment,
Chief Engineer,
Air Canada,
Montreal, Que.

Dr. A. J. R. Smith

Advisers:

Mr. R. D. Hiscocks,
DeHavilland Aircraft of Canada Ltd.,
Toronto, Ontario.

Mr. W. M. McLeish,
Chief, Aeronautical Engineering Div.,
Department of Transport,
Ottawa 4, Ontario.

Dr. G. N. Patterson

Mr. G. T. Rayner,
Treasury Board,
Confederation Building,
Ottawa 4, Ontario.

Mr. R. D. Richmond,
United Aircraft of Canada Ltd.,
Longueuil, Que.

Dr. K. F. Tupper,
Vice-President,
National Research Council,
Ottawa, Ontario.

Mr. R. F. Wilkinson,
Defence Research Board,
125 Elgin Street,
Ottawa 4, Ontario.

Mr. D. R. Taylor,
Director,
Air Industries Association of Canada,
President Aviation Electric Ltd.,
P.O. Box 2140,
St-Laurent, Montreal 9.

First Session—Twenty-eighth Parliament

1968

THE SENATE OF CANADA

PROCEEDINGS
OF THE
SPECIAL COMMITTEE
ON

SCIENCE POLICY

The Honourable MAURICE LAMONTAGNE, P.C., *Chairman*

The Honourable DONALD CAMERON, *Vice-Chairman*

No. 9

WEDNESDAY, NOVEMBER 20th, 1968

WITNESSES:

ATOMIC ENERGY CONTROL BOARD: Dr. George Craig Laurence, President; Dr. D. J. Dewar, Chief Scientific Advisor; and Paul Emile Hamel, Scientific Advisor.

APPENDIX

9.—Brief submitted by the Atomic Energy Control Board.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

29343—1

MEMBERS OF THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Donald Cameron, *Vice-Chairman*

The Honourable Senators:

Aird	Hays	O'Leary (*Carleton*)
Belisle	Kinnear	Phillips (*Prince*)
Bourget	Lamontagne	Robichaud
Cameron	Lang	Sullivan
Desruisseaux	Leonard	Thompson
Grosart	MacKenzie	Yuzyk

Patrick J. Savoie,
Clerk of the Committee.

ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, Tuesday September 17th, 1968:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That a Special Committee of the Senate be appointed to consider and report on the science policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient science policy for Canada.

That the Committee have power to engage the services of such counsel, staff and technical advisers as may be necessary for the purpose of the inquiry;

That the Committee have power to send for persons, papers and records, to examine witnesses, to report from time to time, to print such papers and evidence from day to day as may be ordered by the Committee, to sit during sittings and adjournments of the Senate, and to adjourn from place to place;

That the papers and evidence received and taken on the subject in the preceding session be referred to the Committee; and

That the Committee be composed of the Honourable Senators Aird, Argue, Bélisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, O'Leary (*Carleton*), Phillips (*Prince*), Sullivan, Thompson and Yuzyk.

After debate, and—

The question being put on the motion, it was—

Resolved in the affirmative."

29343—1½

Extract from the Minutes of the Proceedings of the Senate, Thursday, September 19th, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Benidickson, P.C.:

That the name of the Honourable Senator Robichaud be substituted for that of the Honourable Senator Argue on the list of Senators serving on the Special Committee on Science Policy.

The question being put on the motion, it was—

Resolved in the affirmative."

ROBERT FORTIER,
Clerk of the Senate.

MINUTES OF PROCEEDINGS

WEDNESDAY, November 20th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.30 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Belisle, Grosart, Kinnear, Leonard, Thompson and Yuzyk. (7)

Present but not of the Committee: The Honourable Senators Carter and Giguère. (2)

In attendance:

Philip Pocock, Director of Research (Physical Science).

The following witnesses were heard:

Atomic Energy Control Board:

Dr. George Craig Laurence, President;

Dr. D. J. Dewar, Chief Scientific Advisor; and

Paul Emile Hamel, Scientific Advisor.

(*A curriculum vitae of each witness follows these Minutes.*)

The following is printed as an appendix:

9.—Brief submitted by the Atomic Energy Control Board.

At 5.40 p.m. the Committee adjourned to the call of the Chairman.

ATTEST:

Patrick J. Savoie,
Clerk of the Committee.

CURRICULUM VITAE

Laurence, George Craig, M.B.E., Ph.D., D.Sc., LL.D., F.R.S.C. Born in Charlottetown, Prince Edward Island, Canada, in 1905. Physicist in radium and x-ray research, National Research Council, beginning 1930; engaged in nuclear energy research beginning 1940; in the joint British-Canadian Atomic Energy Research Laboratory in Montreal beginning 1942; with the Canadian delegation to the United Nations Atomic Energy Commission 1946-47; with Atomic Energy of Canada Limited until November, 1961, when he left the position of Director of the Reactor Research and Development Division to become President of the Atomic Energy Control Board of Canada.

Dewar, Donald James, M.Sc., Ph.D., P.Eng. Born in London, Ontario, Canada. 1915. 1937, B.Sc. Queen's University; 1938, M.Sc. (Chemistry) Queen's University; 1940, Ph. D. (Chemistry) McGill University, Research Assistant, National Research Council, Ottawa; 1940-46, Armed Services; 1946, Development Engineer, Canadian Industries Limited, Windsor, Ontario; 1955, Scientific Secretary, United Nations Conference on Peaceful Uses of Atomic Energy; 1946, Scientific Advisor, Atomic Energy Control Board, Ottawa (Present position—Chief Scientific Adviser).

Hamel, Paul Emile, B.Sc.A., P.Eng. Born in Granby, Quebec, Canada, 1925. Graduate mechanical and electrical engineer 1952; post-graduate studies in engineering physics 1954-56 at Ecole Polytechnique, Montreal; studies in reactor physics 1957 at the Chalk River Nuclear Laboratories; taught mathematics 1956-57 at Ecole Polytechnique; taught physics at College St. Marie, Montreal, 1959; on mechanical design analysis (NRU Reactor 1953-57) and reactor conceptual design (1957-58) with C. D. Howe Co. Ltd; on conceptual design proposal (CANDU steam generator) 1958, Canadian Vickers; stress analyst gas turbine (PT-6) Canadian Pratt-Whitney Aircraft Co. Ltd., Montreal, 1959; staff scientist Atomic Products Department, Orenda Engines Ltd., Toronto, 1959-62; Scientific Adviser, Atomic Energy Control Board, Ottawa, 1962—.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, November 20, 1968.

The Special Committee on Science Policy met this day at 3.30 p.m.

Senator Maurice Lamontagne (*Chairman*) in the chair.

The Chairman: Honourable Senators, I would like first to express the gratitude of the members of the committee to Dr. Laurence, Dr. Dewar and Monsieur Hamel for the spirit of co-operation they have shown. The Atomic Energy Control Board was supposed, as you all know, to appear before the committee earlier but agreed to delay its presentation when we decided to prolong our discussion with the representatives of the Science Council. Dr. Laurence and his colleagues then accepted to come before us on November 21, that is tomorrow afternoon, but when it was found more convenient to the committee to hear the Department of Agriculture tomorrow, the Atomic Energy Control Board accepted again to accommodate us and to appear this afternoon.

I am sure that all members of the committee are very grateful to the Board for this.

Senator Grosart: Hear, hear.

The Chairman: Now, I have discussed our proceedings for this afternoon with Dr. Laurence and his two colleagues and we have agreed that the brief which was sent to us by the Board would be taken as read, because this I am sure will save time and since we have only the afternoon to discuss the content of the brief I am sure that this will be suitato the members of the Committee.

In addition to the brief, I understand that Dr. Laurence would like to make a brief opening statement and then we will have the usual discussion period.

Dr. G. C. Laurence, President, Atomic Energy Control Board: Mr. Chairman, Honourable Senators, may I first of all introduce to you my colleagues.

Dr. Dewar, on my right, is our senior Scientific Adviser; he has been with the Board since practically the beginning. There is probably nobody in Canada who is better informed on the ramifications and the intricacies of the control and administration of atomic energy in Canada than Dr. Dewar.

Mr. Hamel, on my left, has been with the Board since 1959; he has been in the atomic energy activities since 1952 and he is familiar with all of the aspects of our work.

Mr. Chairman, I am very conscious of the privilege and honour of appearing before this Committee. I have been watching its proceedings since you began and I must say I have been most impressed with your success in the very important objective of exposing to discussion all the aspects of research administration through government assistance in Canada.

I should be most happy to be of any help that we can in supplying information to aid you in your discussions.

As you suggested, Mr. Chairman, I will not attempt to go through the brief; may I though just take a moment to call your attention to its form: it is divided into three parts. The first part deals with the organization and the main functions of the Atomic Energy Control Board and, as you have no doubt seen in reading it, the Board is concerned mainly with regulatory activities in the atomic energy field. Its powers in this regard are exercised mainly in the interests of national security, to make sure that atomic energy materials and equipment do not find their way into unfriendly enemy hands and are used only for peaceful purposes.

Also in the interest of safety to ensure that these dangerous materials and the radioactive substances which are produced through their use are handled in a safe way.

The Board itself is not engaged in research, but it is one of the agencies through which the federal government gives support to atomic energy research in the universities.

Most of the details concerning that which we are presenting to you are given in the second and third appendices of the report.

The Atomic Energy Control Board, as I said, is not itself engaged in research, but it is very much dependent on the assistance it can get from the scientists in other government departments. This we have discussed, indeed in response to one of the questions in your guide, Mr. Chairman, where you express an interest in the interdependence of government departments in the scientific field; Part II, as I say, deals with the aid which we get from these other departments.

Now, the Board through its regulatory activities is in close association with all the atomic energy activities in this country and it therefore has had, if you like, a ringside seat, in watching the progress of atomic energy research and development in Canada. It is a ringside seat which also gives it perhaps a certain objectivity through not being directly involved, so we thought it might be of interest to you if we made some comments on the difficulties which are encountered in atomic research, particularly in industry, so that is the subject matter of Part III.

My colleagues and I would be most happy to respond as best we can to your questions.

The Chairman: Thank you very much, Dr. Laurence. Now we will proceed with the usual question period; Senator Grosart will initiate the discussion.

Senator Grosart: Dr. Laurence, first of all I would say it is a most interesting brief that you have given us and I am sure it will give rise to some interesting questions from members of the Committee. They are not all here at the moment, because the Senate is sitting and we have to divide our energies, but I assure you this is not any indication of any lack of interest in this very, very important subject.

I would like to start my questioning by asking you, if you will, to place Canada and the Board in the international context. Perhaps you would tell us, for example, what is the present status of the non-nuclear treaty—I understand that it requires the signatures of 40 countries in addition to the depository powers, the UK, the USSR and the US—and the effect that the ratification of that treaty by Canada will have on the work of your Board?

Although I recognize the fact, of course, that at the moment your responsibilities are mainly in the domestic field and I know Senator Yuzyk is going to follow me with some direct questions in that area, in spite of that fact I think your Board is going to be much more involved internationally after that treaty comes into effect than you are at the moment. You indicate this, I think, in sections 12 and 13, where you mention the International Atomic Energy Commission and the treaty itself.

In answering I wonder, because we are laymen here, would you also define some of the particular jargon of this subject. Some of us have difficulty in understanding some of the niceties.

For example, why the emphasis on the explosion of fissionable material? The treaty seems to bar the explosion factor, even for peaceful uses and yet in one section of the treaty there seems to be a contradiction, where it indicates that under certain conditions explosion may be allowed by non-nuclear weapons countries, assuming they abide by the regulations of the International Commission.

I think we would be interested in knowing what application the regulations of the International Commission have to Canada at the present moment; do they go beyond the weapons stage? To what extent do they control our own activities in producing fissionable material sources that could be used by another country in the weapons field?

These are a few indications of the kind of information I think would help us put this in context, because there is going to be a very different picture once this treaty is in effect.

I might say that it seems to me a question, and I also wonder why, and perhaps you can enlighten us on this, why Canada is prepared to put itself permanently in a non-nuclear weapons positions when other countries who may not sign, I might think of North Vietnam, are we prepared to bind ourselves for 25 years to a limitation in the nuclear field that might not be imposed, that North Vietnam might not be bound by?

I hope that indicates the broad area of the context that I have in mind that will help us to get into the domestic control aspect of your work, as well as the international?

Dr. Laurence: Mr. Chairman, that is rather a broad area. As you will appreciate, I am sure, it is difficult for me to say very much about the thinking and reasoning behind the policy adopted by our government.

Perhaps I can speak with a little more knowledge in discussing the questions of how it would involve our Board.

First of all, I would remind you of our policy as expressed by the then Prime Minister in 1965 regarding the export of nuclear materials.

If I may quote:

> Export permits will be granted, or commitments to export permits will be given with respect of sales of uranium covered by contracts entered into from now on.

This is June 3, 1965:

> Only if the uranium is to be used for peaceful purposes. Before such sales to any destination are authorized the government will require an agreement with the government of the importing country to ensure with appropriate verification and control that the uranium is to be used for peaceful purposes only.

Well, there has been some clarification and elaboration of that principle since then, but that has essentially summarized fairly briefly our policy.

Now, this means that uranium is not exported to another country without an arrangement with the government of that country whereby the material, first of all, that there is a guarantee that it will be used for peaceful purposes only, and there is provision for inspection to confirm that it is indeed not being diverted to a military use.

The Chairman: Are there any exceptions to this general rule?

Dr. Laurence: There is one exception that is the result of contracts entered into before this statement was made. There are, as you know, some very old contracts for shipment to the British government which did not call for any safeguard measures; this was a natural outcome of our very close association with the United Kingdom and the United States as wartime partners; it followed on from that, but in so far as any new contracts are concerned with any country outside the Canadian boundaries whatever, except for that exception the policy is that there should be appropriate inspections and other safeguards.

Senator Grosart: And that is the responsibility of your Board?

Dr. Laurence: It is our Board in some instances to carry out on behalf of the Canadian government such inspection.

There are some circumstances where the agreement calls for inspection by the International Atomic Energy Agency, you know, the body which was set up some 12 years ago and has its headquarters in Vienna.

There also may be undertakings involving inspection by the inspection arm of EURATOM, the atomic energy aspect of the organization that was brought into being by the treaty of Rome.

Senator Thompson: Could a country have an already-existing pile of uranium and then when you enter into negotiations the uranium that you then sell them, could they sell the existing pile for other than the areas. which your contract permits?

Dr. Laurence: There are certain restrictions involved in the agreements with these countries regarding the disposal of the uranium.

In general I think I am right in saying that in every case no transfer to another power can take place without prior consultation with the Canadian authorities and, of course, that uranium is limited to peaceful purposes.

Senator Thompson: But that is the transfer of the uranium that you sell them, but not what they might already have?

Dr. Laurence: We have no control or means of control over uranium that they already have, naturally.

Senator Thompson: So that the situation could arise that you would sell them uranium in order that they could dispose of an existing pile of uranium?

Dr. Laurence: I am sure that we would not do it in order that they could so do.

Senator Thompson: No, I appreciate that, but it could happen?

Dr. Laurence: It could happen that it would make it easier for them to pursue both a military program and a peaceful program, but so far as any uranium that we supply is concerned, it has to be limited to the civil program.

Senator Belisle: It is also possible for a country who decides that they do not want to pursue or use the uranium that they have that they can sell to another country?

Senator Grosart: No.

Dr. Laurence: Not the uranium which we supply; it could not be sold to another country without consent.

Senator Belisle: It has to be returned to the original supplier, or a new agreement has to be made?

Dr. Laurence: They can continue to use it for the purposes for which it its supply was made under the agreement, but it cannot be diverted to another purpose without consent.

Senator Belisle: But it is possible through another country?

Dr. Laurence: No, it is not possible through another country without consent and such consent so far as I know has never been given; it would certainly be a question which would be one for Cabinet decision.

The Chairman: Would you go on with explaining the role of the Board?

Senator Grosart: Tne International Agency, its role I was particularly interested in?

Dr. Laurence: The Atomic Energy Control Board's officers are in fact the scientific advisers of the Department of External Affairs in the negotiations in this field of atomic energy. Because of its necessarily technical and scientific nature this has involved them directly in a good deal of the discussion and negotiations, but always in an advisory capacity, of course.

The Board's officers, as we mentioned, do undertake inspections abroad where the agreement which we have with the receiving nation says that it is under Canadian safeguards.

The question was raised, I think, Senator, regarding our role under the non-proliferation treaty?

Senator Grosart: Yes.

Dr. Laurence: The non-proliferation treaty requires of such of its signatories that are not themselves nuclear weapon powers that they abstain from the acquisition of such military capacity, nuclear military capacity and also that they submit all atomic energy activities within their territory to inspection by the International Atomic Energy Agency.

This means then, of course, that Canada in signing that treaty would be accepting the inspectors of the International Atomic Energy Agency in its atomic energy facilities in this country.

Now, I fully expect that the Board will be very much involved in this activity in order to act as a kind of liaison between the operators of our facilities and the inspection agencies and I hope that we would be able to fulfil this role in a way which would ease the problem for the operators of these plants by organizing the information and so on, and assisting the international inspectors in ways which will mean that they will not be quite so much an intrusion and create quite so much interference as the operator might otherwise fear in the normal operation of a plant.

Senator Grosart: When you speak of military capacity in this field, what is the test say in relation to explosion? This seems to be the key word throughout the treaty.

Dr. Laurence: Yes; in that treaty as you are reminding me, the non-nuclear power signatories undertake also that they will not develop a capability for peaceful nuclear explosions and the reason for that is that the technology of the peaceful nuclear explosion, the development of the device is identical with that of the creation of the bomb.

Senator Grosart: How much of a limitation is this on the peaceful development of atomic materials for energy and other purposes?

Dr. Laurence: There are those who feel that there are important commercial and industrial possibilities through the use of these nuclear materials as an explosive, such as for digging large ditches. For example, the possibility of building a new dam across the Panama Isthmus has been suggested; the creation of harbours, certain kinds of mining operations, and so on.

There are some problems in this and there are differences of opinion as to the ultimate value and practicability of this.

As I say, there are differences of opinion; some feel that it is quite important and those who are involved in the development of this capability are, of course, its strongest proponents.

Senator Grosart: I do not want you to really comment on this, but I would just like to say at this point that it raises a doubt in my mind as to whether we are not facing an unnecessary limitation of what might be a very important aspect of the industrial devel-

opment of atomic materials in Canada vis-a-vis other countries who may not sign.

We know there are a good many who are not going to sign and with whom we might be in competition in the general race for economic survival.

Dr. Laurence: It should be appreciated, Mr. Chairman, that the non-proliferation treaty does not deny to these states the possibility of benefiting from this use of atomic energy. Indeed, it makes quite clear an undertaking, and the background of discussion in Geneva and so on makes quite clear an obligation on the part of those who possess this facility, to make it available without discrimination to other nations, so that nobody is being denied these commercial possibilities in this regard except in so far as the actual sale of the services might be concerned, and in that limited area possibly one might feel that one was handicapped, but so far as benefiting from this possibility, the benefit is there.

The non-proliferation treaty does not deny it to them.

The Chairman: So that we might ask India to come to Canada and have an explosion for peaceful purposes?

Senator Grosart: Perhaps I can read section 2 of article 3 of the treaty, which is rather interesting, because it is obviously carefully worded, perhaps too carefully worded:

> Each state party to the treaty undertakes not to provide (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material to any non-nuclear weapons state for peaceful purposes unless the source or special fissionable material shall be subject to the safeguards required by this article.

Just what does that mean? Does it mean that one nation that has exploded fissionable material for peaceful purposes may under the International Agency regulations come to Canada and say you cannot do it, but if we can get permission from the International Agency we will blow up some earth for you for the Prince Edward Island causeway?

Is this what this means, or is it a fair question? I do not know whether it is in your ambit to study this.

Dr. Laurence: Perhaps the best way to reply to that question is to consider what would happen if we wanted to move some earth, let us say for the Prince Edward Island causeway.

The detail of this has not been spelled out, but in general it would probably involve the assistance of one of the nuclear power states, the United Kingdom, the United States, France, in doing this for us, and it would be done under certain controls to make sure that those materials which are brought in for that purpose are used indeed for that purpose and are not developed to a military end.

What we would pay for it, it is understood, it is the intention that that would be on a purely cost basis, that there would be no unreasonable profits to the people that did it, but the service would be available to us.

Senator Grosart: One more question; I have a good many questions, but I am going to pass and let others have an opportunity to ask their questions: are there existing regulations under the International Agency applicable to Canada or other countries in the peaceful development field?

Perhaps I can put it another way, that throughout your brief you indicate what you are doing in setting safeguard standards. Are these purely Canadian standards, or are there international standards in the peace-using field; I am not speaking of the weapons field?

Dr. Laurence: In our signature to the International Atomic Energy statute, we have undertaken, of course, to support it and the ends for which it stands, in particular the encouragement of the peaceful uses of the atomic energy throughout the world and the other principles laid down in the statute, which includes a responsibility to make sure that through that agency no aid is given to another nation without necessary adequate safeguards that it will be used only for peaceful purposes.

Now, this means certain safeguarding procedures; the International Agency has set up committees of experts to advise us in this regard. Canada has contributed to these discussions through officers of the Board. They have developed a set of procedural rules for this safeguarding, that is to say, basic principles.

These principles of the International Agency, these safeguards are principles of the International Agency, because they are accepted by that agency, have a certain international status; they are recognized as sound

safeguarding principles. Hence in our own safeguarding under those arrangements where we are supplying uranium and so on to another nation under a bilateral agreement which calls for safeguarding by Canadian officials, we are guided by these international principles. We take them as the pattern which we shall follow.

Senator Grosart: But do they apply in Canada? Are we required to live up to certain standards of non-pollution, non-radiation standards, and so on? Are we required to live up to any international standards?

Dr. Laurence: No, we are under no obligation by any international agreement.

Senator Grosart: That is all for now, Mr. Chairman.

Senator Thompson: Could I just follow up on that question?

The Chairman: If it is supplementary, because Senator Yuzyk is waiting.

Senator Thompson: Yes, it is supplementary, really, to that, because you are a regulatory body and with this world inspection, if you set up a nuclear power plant, assuming the affluent in the stream or something is higher than you think is satisfactory for the safety of the population, you have no authority, or your inspectors, to close that plant down; am I right in that?

Dr. Laurence: Oh, certainly we have.

Senator Thompson: Under what basis? Under international standards?

Dr. Laurence: No, under our own laws.

Senator Thompson: No, I am talking about not here, but if you are helping India to set up a plant, or if you are invited somewhere else to do it?

Dr. Laurence: No; we would have no authority there, either under or not under the international non-proliferation treaty.

Senator Thompson: So that when we set up a power plant somewhere there are no guide lines for inspectio nto ensure the safety of the population in that area?

Dr. Laurence: Unless that has been specially arranged as a service.

One should here make clear distinction between the inspection of a plant to ensure safety from the hazards of radiation and safeguards to ensure that materials are not being misused for military purpose, or developed to such an end.

These are two quite distinct reponsibilities.

Senator Thompson: Well, I was following on Senator Grosart's question, in which I think he brought up, it was the second area of safety, when you are putting it in for civilian purposes, but the precautions to ensure that an affluent and other sources of radioactivity is not harmful to the population.

As I understand it there are no international laws with respect to that.

Dr. Laurence: No, I cannot think of anything; no, there are no international obligations.

Of course, throughout the world certain basic standards are recognized. There is a body of very long standing, the International Committee on Radiological Protection, which goes back to 1924. It was recognized as the authority to lay down guiding rules as to what we should regard as a non-acceptable hazard, a non-acceptable danger in the matter of radiation exposure.

Senator Thompson: I do not want to take a lot of time, but do you not feel, as the regulatory body for Canada, that this is something we should be pushing for?

Dr. Laurence: I think that we should recognize the same standards throughout the world and in so far as the fundamental basis of these standards is concerned, that is in fact true today, but what is spelled out in regulations with statutory authority behind it in different countries is a different matter.

Senator Belisle: To your knowledge, doctor, was there any case, or any attention brought to the world court at The Hague regarding these matters?

I am speaking of the justice court which is under the world, or the United Nations?

Dr. Laurence: I think I am right in saying that there has never been an occasion where such a matter has been brought before that court.

This, Mr. Chairman, I presume would depend on if there had been some treaty that it would appear had been violated; I am not a lawyer, but I would think that this would be the case.

Senator Grosart: Mr. Chairman, on that perhaps I think we might consider calling at

the appropriate time the atomic agency control department or section in External Affairs.

I know you have very close relations with them, but perhaps this question should be asked of them.

Senator Yuzyk: I have about three questions: one, I want to quote right from your brief, because I think this is very important and that is about the Atomic Energy Control Board:

> Its chief purpose is to control nuclear and radioactive materials and nuclear energy equipment in the interest of national security and of safety from radiation hazards.

This is a very grave responsibility and, of course, I think the people of Canada would want you to be as effective as possible in carrying out this aim and that is why I will be asking some of these questions.

First of all, about the organization itself, I note that there are five persons here that are members of the Board and my question is this, I have two questions regarding this: Why only five members of the Board, particularly when we have to keep in mind that the uses of nuclear energy are expanding terrifically and it will need probably much more attention than five?

Another, that some of the members of this Board, particularly Dr. Gray, president of the Atomic Energy of Canada, and Dr. Schneider is on the Board, president of the National Research Council, are in the same body controlling themselves, so to speak, and there are only three others who could probably, if they had a different point of view regarding certain hazards and what should be done, the other three might find themselves in a weaker position to do something about it.

The Chairman: I think, Senator, if you want to pursue this line of argument you could also add Mr. Gilchrist, who is the president of Eldorado Nuclear Limited.

Senator Yuzyk: That is right; Mr. Gilchrist, too, because in these hazards and safety they are involved and their activities would be involved too, and their operations, so my question is this: why, since the public is very much concerned, the common citizen, why is there not some representation from the citizens on such a board?

Another: since your Board is involved with the universities right throughout the country, why is there not any representation from the universities and thus in bringing this matter up I would think that there would be a wider representation to discuss these problems and make important decisions?

That is the first question.

Dr. Laurence: I suppose the quick answer, Mr. Chairman, is that the Atomic Energy Control Act specifies that there should be five members. At the time that that act was passed it was expected that the Board would play a much more important role in advising the government on all aspects of atomic energy matters than it does in reality now.

Its functions have become somewhat more specialized and restricted since then. So they designated for the Board persons whose official responsibilities were such that they would be best informed on the important aspects of atomic energy matters which is, as you realize, a highly specialized, a highly technical subject.

There are advantages in small size, as you well know, in endeavouring to get a committee together for any purpose.

There was also mentioned the question of university association.

Senator Yuzyk: And citizens.

Dr. Laurence: I was going to remark that until recently Mr. Gaudefroy was Dean of the Ecole Polytechnique in Montreal and did bring that university representation directly to us.

The Board in its discussions is concerned mainly with very broad principles of policy. The questions which you are raising, details of safety, and so on, the Board would not be expected to get into that kind of detail. The provision that we have for that is through advice by advisory committees, which do make provision for local representation, provincial representation. Even the municipal officer of health is brought into the discussions of our Reactor Safety Advisory Committee.

That committee really is a very powerful body; the Board has never gone against its recommendations that I can recall, and I think it would hesitate a long time to do so.

So there is that representation of the people immediately affected on the level where it is important.

The Chairman: What is the membership of that committee?

Senator Yuzyk: Yes, we did not have that specified at all and I am very glad that you brought this in.

Senator Thompson: Just while you are looking for those members, could I come back: Senator Yuzyk had read out your priority of purpose and surely that is, if I could just quote again from page 1:

> —the interest of national security and of safety from radiation hazards.

Again accepting how technical this area is and that there are not a large number of people, it is almost like a manufacturer of an aircraft being the inspector of the safety of the aircraft to me. With the deepest respect for the sincerity of these people to the public and to myself there would be a question of how really objective they can be at times in saying that this really is not satisfactory to the public.

I think, for example, of Port Hope, where you have some young university professor coming out and suggesting that there is danger for the people working in Port Hope from the radioactive material.

Dr. Laurence: Again this is a question of detail in administration which hardly would come up for discussion in a meeting of the Board. The Board would concern itself with broad principles of policy. Whether or not, for example, we should continue to be guided by the basic principles outlined by the International Committee on Radiological Protection, a broad policy consideration of that kind, that kind of policy question.

What we have been discussing here are matters of administrative detail and I think the question of providing adequate protection, really the responsibility there rests on the Board's staff and on the administrative head of that staff to make sure that we do our job.

The Chairman: I know that you are not responsible for these appointments, Dr. Laurence, but it seems to me a little bit awkward that in this case the people who are supposed to be supervised and regulated find themselves also in the position of supervisors and regulators.

Even if, as you say, the Board itself is concerned only with the broad and basic principles of policy, it seems to me that they are quite important too, and in terms of a conflict of interest I am sure that there is no actual conflict of interest there but in terms of organization and division of labour it seems at least awkward to me that we find these people on your Board.

Dr. Laurence: I can only say, Mr. Chairman, that I have never been conscious of any reason for embarrassment of this kind from the point of conflict of interest.

Of necessity many of the members of the Advisory Committee on Reactor Safety are scientists who are employees of one of these organizations you mentioned, Atomic Energy of Canada Limited.

I say "of necessity" because at least until recently there were no other scientists of comparable competence in these specialized fields in Canada; this was the best advice that we can get.

I myself have retained the chairmanship of that committee, so I am very familiar with its activities and if there are any of its members who are most careful to be objective in their judgment it is those who feel that they are in that conspicuous position.

This has never been to my mind a cause for any concern.

The Chairman: Perhaps we could get the list of the members of the committee.

Dr. Laurence: This is the Reactor Safety Advisory Committee, the committee which advises the Board on whether it will accept a certain site for the location of a reactor, whether its design is satisfactory or not, as to whether the operational procedure is satisfactory or not.

May I interpolate here before I go on to the list that this committee is a very hard working committee and the staff which is behind it goes into the design and the operating procedure of these plants with very great care and their discussions in the meetings have led to quite important changes in the design. It is an effective committee: it is no mere rubber stamp. This I want to stress.

Now, to come to the composition: myself as chairman; Dr. Booth, who is of the Department of National Health and Welfare; Dr. Davis, of the Defence Research Board; Mr. G. M. James, who is the Manager of the Operations Division of Atomic Energy of Canada Limited at Chalk River; Dr. Larkin, National Research Council; Dr. C. A. Mawson, of Atomic Energy of Canada Limited; Mr. N. S. Spence of the Department of Energy, Mines and Resources; Dr. C. G. Stewart of Atomic Energy of Canada Limited; Mr. Boyd of our own staff is the secretary.

Now, that is the basic standing committee, but it is our practice that where a proposed plant in a particular province comes under consideration, or a particular location comes under consideration, to bring in the appropriate provincial officers and local officers. So we have members for Ontario Reactor Projects, which include Dr. Leppard of the Ontario Department of Health; Mr. Gibson, of the Ontario Department of Labour; Mr. H. A. Clarke, Division of Industrial Wastes, Ontario Water Resources Commission.

For the Quebec Reactor Projects: Dr. R. Bourassa, Chief Medical Officer, Division of Industrial Hygiene, Quebec Department of Health, Montreal; Mr. Aumont, Physicist, Division of Industrial Hygiene, Quebec Department of Health; Mr. Lapointe, Technical Services, Quebec Department of Labour, Quebec.

Members particularly for the NPD Project, that is the one as you know up the Ottawa River near Chalk River: Dr. R. Bourassa, who I mentioned before; it is a Quebec member here because there is a considerable territory of Quebec adjacent and the province of Ontario is also represented.

Member for the McMaster University Project: Dr. Wells, Medical Officer of Health, Hamilton.

Member for the Douglas Point Project: Dr. D. R. Allen, Director and Medical Officer of Health, Bruce County Health Unit, Walkerton.

Members for Pickering Project: Dr. A. R. J. Boyd, Medical Officer of Health, Administration Services, Toronto; Dr. C. M. Hoffman, Medical Officer of Health, Ontario County Health Unit, Whitby.

That completes the list, Mr. Chairman.

(*A short recess.*)

UPON RESUMING

Senator Yuzyk: Pursuing the same theme I would like to ask Dr. Laurence and the other members whether you would be opposed to an expansion of the Board by two members to make it more representative and from my point of view even more effective in the future?

I think there are members in our own Committee who are very much interested in the effectiveness of this Board and in asking these questions we like to get your opinions too, if it does not jeopardize your position.

Dr. Laurence: Well, Mr. Chairman, my own feeling is that we want to have as effective and as efficient a committee as we can conceive for the purpose.

The Chairman: Were you speaking about the Board or the Committee?

Senator Yuzyk: No, I am talking about the Board actually; as I brought out, there are three who are involved and yet they are the ones who are to be inspected too, and the other two are not.

Dr. Laurence: First of all, Mr. Chairman, might I remark that the inspection of these agencies to which you refer represent only I would say a minor part of the inspection, only a minor part of the Board's activities.

The Board's activities extend far beyond those boundaries; there is all the inspection which is involved to ensure that radioactive materials are used in a safe way; there is our involvement in safeguarding abroad, and so on. It is true of two nuclear power stations, three in fact, that Atomic Energy of Canada Limited has played a quite important part in the design of these plants and that has been subject to review by our committee, but I do not think anyone who has been involved in this safety inspection would claim that our safety committee has been any more lenient for that reason.

Senator Yuzyk: I am not casting any aspersions on the present Board; I am just thinking of the future, that we could get into situations that could create problems right within the Board itself and that is why I asked the question.

I was wondering whether you would be opposed to any such recommendation, if we made it; I am not saying that we are going to make it.

Dr. Laurence: One of the things that occurs to me, of course, is the ever-present difficulty of getting a large committee together; we always have difficulty, even with a five-member committee.

There is also the fact that the present members of the committee do have considerable background in the atomic energy field and this, I think, expedites their work very considerably.

Senator Yuzyk: You would be satisfied with the present set-up?

Dr. Laurence: I would be satisfied, yes; if there was any enlargement at least I would hope that they would be people who had considerable background in atomic energy technology.

Senator Yuzyk: Now, if I may ask, how often do you meet?

Dr. Laurence: By law we must meet three times a year, and we barely make it.

Senator Yuzyk: And how long do you sit when you do meet; how many days?

Dr. Laurence: It may run from three hours to most of the working day.

Senator Yuzyk: And you can dispose of most of the business before you?

Dr. Laurence: Yes; the chairman has to keep pushing to get through with it.

Senator Grosart: From some of the evidence we have had concerning other boards, some of us have reached the conclusion that one of the deficiencies that may be operating against their total effectiveness is the fact that they are part time boards. The Science Council, for example,—here we have a council or a board in your case which has this tremendous responsibility; it is a part time board, some of its members; it meets three times a year.

Can this be effective? Can a part time board do this job? I would not want to accept the responsibility as a part time member of this board, because it is a terrible responsibility.

Dr. Laurence: Mr. Chairman, a moment ago I referred to the advantage of having people with a broad technical background in this; this is a great advantage to us, to have people who really are well informed on all the aspects.

Senator Grosart: Excuse me; I was about to say that I appreciate the fact that we just do not have enough scientists to go round.

Dr. Laurence: Yes, but also what we are bringing together in that board is people who know the full background behind the policy and so on; they are knowledgeable people and they are only knowledgeable because they hold the positions they do and they would not be able to hold those positions if they were full time members.

You cannot, as it were, have it both ways.

Now, that being so, that is we depend on them for the guidance that has behind it the wisdom of their responsibilities and experience, it means that the Board's staff deals with the day-to-day detail. If you would ask me do I think the Board's staff should be enlarged, I would agree.

Senator Grosart: I see you mention that in your brief.

Senator Thompson: Just following on your principle: why would you object to having someone from Elliot Lake uranium mines, or from the private sector on the Board, or would you object?

Dr. Laurence: I see no particular reason to object there provided we fulfil the principles that I have mentioned.

Senator Thompson: You do not see a conflict of interest for someone from the private sector being on the Board?

Dr. Laurence: I am sure that we would have no more difficulty in that regard than we have with the present membership of the Board.

Senator Thompson: Would this be useful, because actually I should give credit to Senator Grosart, who had to leave the room for a moment, about a consumer being part of the Board? Would this not bring a practical knowledge to the decisions of the Board?

Dr. Laurence: You will remember that we do have on the Board Mr. Gilchrist, who has a long background of experience in the mining business and certainly meets that requirement.

There is another point here that I should mention, that often discussions are involved with matters of national security and government policy which should not be entrusted too widely, and for this reason there has been a tendency, not completely, but almost completely, to restrict it to federal government employees.

Senator Grosart: Dr. Laurence, it seems to me there is this problem, that experts handling dangerous problems tend to become enured to the risks inherent in the problems.

I read an article not very long ago about the famous Caughnawaga Indians and their high steel capabilities and somebody who was an expert was asked if they really are such great steel workers as we are told. He said yes, but they are a damn nuisance, because

they are so skilled that they will just brush by you on a 12-inch plank 50 storeys up, they are so sure of themselves.

I wonder if there is not something of this in Senator Thompson's question, a thought that we should have some "scared" people on your Board, some ordinary civilians who are scared to death about the possible dangers of atomic fall-out, radiation, effluents, pollution, and so on.

Dr. Laurence: Mr. Chairman, it seems to me that this concern about familiarity breeding contempt is very true of the people who are using these things, but not of the people who have a responsibility to ensure that they handle these things safely.

At times I am a little concerned that we are trying to do too much, that we are setting standards which in our idealism and our enthusiasm to protect the people may go a little too far beyond reason and are impracticable, so I think that the question of familiarity with the hazard making one careless is very real on the part of the user, but I do not think on the part of the regulatory bodies' employees.

Senator Thompson: If I could just follow on your Advisory Committee, as I listened to that, all of those people were civil servants on the Board's Reactor Safety Advisory Committee. Having once been a civil servant myself—well, I will put it this way, sometimes discretion is the better part of valour.

The point of raising an outraged cry against your government is not the practice of civil servants. Again, following Senator Grosart's point of view, there are people who are scared, perhaps without justification and on your Advisory Committee there are people who by practice, indeed by law, are not supposed to speak against their government, or else they should resign.

Would it not necessarily be useful to have some people from the private sector?

Dr. Laurence: Mr. Chairman, you will notice that in addition to present and ex-federal civil servants there are also provincial civil servants and also municipal officers.

Senator Thompson: Yes, I did recognize that, but they are all civil servants and the point I am making, with the deepest respect for the value of the civil servants at any level, an advisory committee in this very sensitive area I think should include people from the public sector, that is, other than the government.

Dr. Laurence: I cannot recall any occasion on which a question arose in the proceedings of this committee which could be regarded in any way challenging government policy.

Senator Thompson: Perhaps it should have; if it did happen what would be the situation?

Dr. Laurence: Our basic guide is the principles which are recognized internationally, or what is regarded as sound practice in engineering generally and particularly sound practice in the restricted field of nuclear engineering.

Senator Grosart: What is the degree of independence of government of the Board? Is it as independent as the CBC?

Dr. Laurence: I am not sure I understand the question.

Senator Grosart: There is a trend today in certain fields to give responsibilites to a board that has a very high degree of independence.

I mentioned the CBC as one for obvious reasons. True, that it reports through a minister, but the present minister, Mr. Pelletier, has made it very, very clear that he welcomes the independence of the CBC and the CRTC.

The Chairman: I went through this too.

Senator Grosart: Yes, of course; I should apologize to you, Senator Lamontagne, because I think you are the author to some extent of the new look in broadcasting; I will say no more than that.

What is your relation to government; to whom do you report?

Dr. Laurence: We report to the Honourable Mr. Greene as the minister designated for the purpose of the Act and not by virtue of his departmental portfolio.

The Chairman: Have you always reported to the Minister of Energy Mines and Resources?

Dr. Laurence: No; there was a time there when we reported to the Minister of Trade and Commerce. There have been changes over the years; it has I think perhaps been a question of the particular interests of the minister in question.

Senator Grosart: Which minister was that? I did not get it?

Dr. Laurence: The Minister of Trade and Commerce at one time.

Senator Grosart: No, at the present time?

Dr. Laurence: At the present time it is Mr. Greene.

Senator Grosart: Mr. Greene?

The Chairman: As Mr. Greene; not as Minister of Energy, Mines and Resources.

Dr. Laurence: That is the point that I was trying to make, Mr. Chairman. He has been designated for the purposes of the Act.

The present reading of the Act is:

> 'Minister' means the Chairman of the Committee of the Privy Council on Scientific and Industrial Research as defined in the Research Council Act, or other member of the Queen's Privy Council for Canada designated by the governor in council as the Minister for the purposes of this Act.

The Chairman: There are a lot of words.

Senator Yuzyk: Perhaps we should go on to some other fields here too; I have a question about the permit system, since this is I think the way that you are carrying out your function, through the permit system and then another comprehensive licensing system.

Could you just explain, have you set up certain standards, is that it, in licensing and issuing permits, that are known?

The Chairman: To the general public?

Senator Yusyk: I would say to the general public mostly here, yes.

Senator Grosart: Or that are a matter of record?

Dr. Laurence: To begin with, there are the regulations; these lay down the basic principles of care and protection against radiation and handling of these materials. These are in our regulations.

Senator Grosart: Mr. Chairman, I wonder if I could suggest that Dr. Laurence might let us have those regulations; I think it would be very useful to have them as part of our record.

This is really what we are talking about; what are the regulations?

Senator Yuzyk: This is carrying out policy and I think this is important for us.

Dr. Laurence: It was my intention to distribute, I am not sure if this has happened or not, copies of our last annual report, which does contain our Act and the regulations.

Senator Grosart: I think that would be sufficient.

The Chairman: Will you make that available to Mr. Pocock?

Dr. Laurence: Yes. In regard to reactor safety, it must be understood that the technology here has been changing so rapidly that it is quite impossible to draw up a set of rules. Almost every reactor brings along new problems and all we can do is rely on the good judgement of the experts on our committee.

Senator Yuzyk: Which leads me to this question which I was going to ask anyway: Do you spend any money on research yourselves, research on safety, safety factors, safety devices and improvement?

Dr. Laurence: Mr. Chairman, you may gather from Dr. Dewar's expression that he is very pleased that that question has been raised; we have not been.

Now, as has been pointed out in this report, an important part of our budget is money which is intended for the support of research in universities and in our submissions on behalf of this budget allocation it has always been understood that this was for research on basic science or closely applied science, but not for this particular purpose that you mentioned.

The Chairman: Why is this, you being a control agency and having two very important regulatory functions, that you are involved in assisting pure science research in universities?

Dr. Laurence: I think, Mr. Chairman, it is mainly because the importance of this other matter has not impressed itself on our consciousness until quite recently, but now there is a feeling that we should budget for it, mainly because it may be neglected otherwise; we should budget for research directed directly towards safety matters and also safeguarding matters.

Senator Grosart: Dr. Laurence, you used the phrase "this money in your budget is intended," then I think you said "it has

always been understood;" this disturbs me a little, because I see this trend right through the whole R and D picture, that there are bits and pieces of R and D allocations from all sorts of departments and we have not had any evidence before this Committee yet that they are really co-ordinated.

I wonder if this is not something that has developed politically over the years, that governments have said you give a little to universities, you give a little to somebody else for basic research, because it is incredible when you look over the whole picture to see the number of decision makers there are adding up to the final decision as to our total public investment in R and D.

I would say it is impossible to co-ordinate the proliferation; we should have a non-proliferation treaty in R and D grants.

This brings us right down to the question you have just been asked: we have discussed this and we have been amazed to find that you were letting ou this very, very important function. You speak in your brief of the requirement of better instrumentation, proved and more sophisticated instruments for detection, and so on, and yet you are using the research money for grants—I am not criticizing you, because I know how these things develop; I know how hard it is to change a vote in the estimates.

The Chairman: Or even the legislation in this case.

Senator Grosart: Yes; perhaps we should come to that: Does the legislation require you to make up your estimates in this particular fashion? That is to say, does the legislation require you to let out or to allocate this very, very large proportion of your budget to other R and D entities?

Dr. Laurence: Mr. Chairman, the relevant paragraph in our Act is paragraph 8; I will not read it in its entirety, because it deals with other matters as well.

To quote:

> The Board may, without limiting the generality of any other provision of this Act, establish, through the National Research Council or otherwise, scholarships and grants in aid for research and investigations with respect to atomic energy, or for the education or training of persons to qualify them to engage in such research and investigations.

The Chairman: This is on page 6, as you know, of the memorandum.

Dr. Laurence: Now, the language there has a strong suggestion that this aid should go to the universities for the fostering of research there. That, of course, does not exclude the possibility of research on safety matters, and so on, in the universities.

Senator Grosart: Do you take the wording it "may" as meaning it "shall"?

Dr. Laurence: No, no, indeed not, but it does indicate an intention or a possible desire on the part of those who framed the legislation.

Senator Grosart: We have had lawyers tell us in other contexts that "may" means "shall"; that is why I asked the question.

I have never understood why any lawyer contorted the simple English language that way, but they do, I am glad to see you do not.

Dr. Laurence: Mr. Chairman, I have just been reminded that I should point out that this is "may" with the approval of the Cabinet, of course.

Senator Grosart: Yes; you say you are authorized to?

Dr. Laurence: Yes.

Senator Yuzyk: I have one more question: I was reading a very interesting article in the International Research and Technology Journal by T. B. Taylor and I must confess that he almost scared the daylights out of me in dealing with the problems of nuclear energy. I am just going to quote two pertinent sentences:

> While the special nuclear materials required for nuclear explosives are rapidly accumulating throughout the world, the knowledge required for the construction of nuclear explosives is also spreading rapidly.

And he deals with the fact that individuals can now use some of these materials for their own purpose; then, a little later on he states, and this is regarding the United States:

> Nuclear explosives secretly placed in several large cities could be used for blackmail to force city, State or federal governments, perhaps more than one, to take certain actions and also that non-national organizations, perhaps even

> existing criminal organizations are likely to be tempted to divert or openly steal special nuclear materials for an international illegal market—,

And so forth. In other words, we have got ourselves now to the stage where the control has to be greater than ever before, because once it gets out into the public and there are interests and subversive interests involved, this becomes a very serious matter for the country and for the governments.

My question is this: you must be discussing this situation; perhaps it is not very apparent in Canada, but it does not take very long for this knowledge, or some of these materials that could be stolen, and it explains here how easily it could be done, that these materials could be brought into Canada and could be used to threaten our very government and way of life.

My question is, are you giving consideration to these possibilities in the very near future in order to do as much as possible to prevent such action of organizations or individuals?

Dr. Laurence: The answer in brief is, yes, a great deal of consideration has been given to this.

Now, to elaborate the answer a bit, it is just for the reason that you have pointed out that the non-proliferation treaty makes no distinction with regard to the control that is to be exercised over nuclear weapons or the materials that go into their construction and explosive engines for civilian purposes.

That is why there is so much attention, so much importance has been attached to that in the discussions that let to the drafting of the non-proliferation treaty.

Again I would stress the point that the device which you use for a nuclear explosion for civilian purposes is a nuclear military weapon used for a civilian purpose; it is the same kind of device. It requires the same kind of materials; it has the same technology and knowledge behind its construction.

Senator Yuzyk: How much can be done to detect, say, the theft of these materials that could be used by individuals or organizations, undesirable individuals and organizations?

Dr. Laurence: It is the purpose of safeguards inspection to make it as difficult as possible to divert materials to such uses as you mentioned.

Senator Yuzyk: I have one more question and this is the last. Following this up, do you not think it is very important to have funds, special funds allocated to make this system of detection as foolproof as possible?

Dr. Laurence: Yes.

Senator Grosart: How much does it cost to develop nuclear capability to the explosion point?

Dr. Laurence: It depends a bit on what you start with.

Senator Grosart: Well, how much would it cost in Canada, starting from scratch?

Dr. Laurence: Not enough to make it prohibitive.

Senator Grosart: Is that so?

Dr. Laurence: For Canada.

Senator Grosart: Millions, hundreds of millions?

Dr. Laurence: It would be the scale of $100 million I should think; is that a reasonable guess?

Dr. D. J. Dewar, Chief Scientific Adviser, Atomic Energy Control Board: Less than that, if you just wanted a few weapons.

Senator Grosart: I think what is worrying Senator Yuzyk is that that might not be beyond the capability of the Mafia.

Senator Yuzyk: No; I am convinced from this article that it can be done, that they can assemble their materials and all that they need to do is to steal, is it plutonium or some of these other materials, and then just bring it into their own machinery, which can be built up secretly.

This is what worries me and I understand that that would not be too costly and that a Mafia certainly can handle such a problem.

Dr. Laurence: He needs the materials and he needs the knowledge.

Now, as you know, there are two nuclear explosive materials which have been used in the weapons so far: uranium 235; separation of this explosive material from the natural uranium is a rather expensive process. The other material is plutonium and that is produced in most kinds of nuclear power sta-

tions. It is produced in our Canadian nuclear power stations and many of the nuclear power stations in other parts of the world. This material can be obtained; at the moment it is a waste product from these plants, or has been so regarded. It is carefully stored, partly for safety reasons, but it is there.

Senator Thompson: And this would apply also to any nation which might set up a nuclear reactor, for example? Very easily and quickly they could turn this into a nuclear bomb?

Dr. Laurence: Mind you, it requires considerable technical knowledge to fabricate an effective and efficient nuclear weapon.

Senator Grosart: You do not just have to read papers?

Dr. Laurence: If you can get hold of the right papers it would help a great deal, but even so you might want to do a few experimental explosions.

Senator Grosart: The treaty seems to insist that all information be shared in common. It seems to be one of the strongest features of the treaty, requiring complete international sharing of all information even at the explosion level.

Dr. Laurence: I think there may be some misunderstanding here, Mr. Chairman: information on how you use the device is to be shared, but not on how you make the device.

You might make a comparison with a stick of dynamite; it is one thing to tell a person how to use a stick of dynamite in an engineering operation, but an entirely different thing is to tell him how to make a stick of dynamite.

Similarly, may I say carrying the comparison further, it is as if there was indicated a readiness to tell people how to use dynamite, but not how to make it.

Senator Grosart: Article 5 reads in part:

> Potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear weapons states party to this treaty on a non-discriminatory basis and the charge for such parties for the explosive devices used will be as low as possible and exclude any charge for research and development.

Now, this seems to contemplate making available explosive devices, subject to the International Agency, of course.

Dr. Laurence: Under safeguards to ensure that the control over them is maintained.

What I might well imagine would happen is that the nation which produces these things would take these devices into the country where they are to be used and maintain direct control over them until they are destroyed through their use, so that the control did not fall out of their hands.

Senator Grosart: I could see your Board having a very important function, both internationally and domestically. It is not very often that a parliamentary committee is worried about an agency of the government not spending enough money to do its job, but I think we are a little worried.

Could I ask you this question: Having in mind your recent experience that you have mentioned, is it your view now that the Board should be provided with the capability of doing more research in this particular field of safeguarding?

Dr. Laurence: It is my opinion that funds should be provided for the doing of this research, not necessarily by the Board, if we can contract to have it done by somebody who is engaged in research.

The Board all along has avoided becoming involved itself in research, and I feel myself it should continue not to get involved in research, but the time has come when we are very conscious of the need for developing and perfecting instruments of this kind.

Just at the present time discussions are going on about the possibility of investigations of this kind, discussions looking into the possibilities from a technical point of view purely at the moment, but I could well foresee that we may soon need funds, may soon want fund for such a purpose.

The Chairman: You do not feel at present that as the Act stands now you are in a position to contract out research in this field?

Dr. Laurence: No; I see no difficulty there under the Act of providing funds for such a purpose.

The Chairman: You can provide funds, but it depends on the method; you see, grants and aid usually are awarded on the basis of application, while the power to really ask people to do that kind of research on a contract basis I do not think would be covered by the Act as it stands now.

I am not a lawyer, but the reference here is to scholarships and grants in aid for research and investigations.

I suppose that that is wider in scope; in any case you feel that you could at the moment within the scope of the present Act contract out research for the purposes of your activities and responsibilities?

Dr. Laurence: I am not sure of the answer to that question, Mr. Chairman. One of the provisions in the Act is that the minister may undertake or cause to be undertaken researches and investigations with respect to atomic energy, so I feel that ways and means could be found to provide for this research on a contractual basis.

Senator Yuzyk: But you would have to go to the minister in this case and convince the minister that this was necessary; would it not be better to have it within your powers?

Dr. Laurence: In any case we would have to go to the Treasury Board.

Senator Grosart: They are the science policy decision makers at the moment.

Senator Giguere: The USA and Great Britain must have significant programs; do you have access to that information?

Dr. Laurence: There are certain agreements between the government of Canada and their governments dealing with the exchange of information in certain areas.

Senator Grosart: How many entities attached in one way or another to the Canadian government are involved in this problem of nuclear development?

You mentioned the AECL and there is the section, or whatever it is, in External Affairs; there is the NRD. Is there anybody else?

Dr. Laurence: Eldorado, of course, and some of the sections of Mines, Energy and Resources that has been involved; the Geological Survey; the Mineral Resources Division.

The Chairman: Trade and Commerce.

Dr. Laurence: On the export and import, certainly; yes.

Senator Grosart: And on the safety side you have got a couple of hundred in the pollution area. I was reading some evidence given before the Commons Committee and I started to write down the number of agencies engaged in the anti-pollution business and I ran off the page, which raises this question: Have you any constitutional problems? Perhaps not to make it a leading question I would like to quote you from evidence given by Dr. Price, the Director of Inland Waters of Mines, Energy and Resources, who made this, to me, amazing statement. It occurs at page 55 of the Minutes of Proceedings of the Standing Committee of the House of Commons on National Resources and Public Works.

Dr. Price said:

> The question of radioactive waste again falls under federal jurisdiction, but even that I believe in the case of Ontario has been passed over to the province for enforcement.

Now, I take it that I "believe" is rhetorical, because it would seem incredible that somebody like Dr. Price would not know whether the jurisdiction in the matter of radioactive waste had been passed over to the Ontario government. Have you any problems in this area?

Dr. Laurence: It has been in general our practice, and I mentioned this earlier, to avail ourselves of assistance of departments which have regulatory responsibilities that are closely related. We do this by nominating some of their officers as inspectors on behalf of the Board; in this way we bring them directly into these problems.

Senator Grosart: And this is not passing over your jurisdiction?

Dr. Laurence: This does not pass over our jurisdiction, but it does mean in effect that they do the job on our behalf.

Senator Thompson: But on this point I have been interested on this question: I notice the composition of your Advisory Board on Safety Regulation includes municipal, provincial and federal. Now, in the question, say, of transportation of radioactive material the province would have some jurisdiction concerning roads and the size of vehicles, and so on, water pollution, as I understand it, and I have just a little background in connection with various situations that happened at Elliot Lake and at Port Hope.

When there was an initial scare about the situation, that they had fish and so on in these lakes affected, there was a test force then sent up which was made up of deputy ministers of the province of Ontario. They were going to examine the situation, but I

would have thought in view of your constitutional prerogative that you would have been the people to examine this and then tell them what should have been done.

Dr. Laurence: We carry the responsibility in this matter but since we have asked the provincial departments to co-operate with us in the way that I indicated, that is having their officials act on our behalf, we try not to interfere in the detail. That is, we, having delegated a certain responsibility, stand behind it so far as enforcement is concerned, but we do not complicate things by sending in other inspectors acting directly on our behalf.

Senator Thompson: Could I just take that one example; I would like to go back to transportation again, the example of say Elliot Lake, the municipality is concerned. This was about six years ago; the municipality is concerned because it is adverse publicity to their tourist trade.

Dr. Laurence: I have just realized what committee you are referring to here. I was present in the important discussions of that committee which bore on this matter and participated in it. Also on occasion one or two other of our officers were with me.

Senator Grosart: There is no doubt in your mind that you have jurisdiction, in spite of the oft-repeated dictum almost of the provinces that if pollution originates on shore it is their responsibility; it is only a federal responsibility if it originates in navigable waters.

There is no question in your mind of your jurisdiction in this whole field of safeguarding the public from nuclear hazards?

Dr. Laurence: Our jurisdiction applies to the operation of the mines or the other facilities that might be the source of this pollution. We can exercise control within the fence and that is usually where the control has to be exercised, but it does call, of course, for close collaboration with the provinces and it is always our policy to consult with them and make sure that we use our authorities in a way which meets their normal needs.

The Chairman: Atomic energy in all its aspects, as you are aware, has been declared to be in the general advantage of Canada, so it comes exclusively under the federal responsibility.

Senator Grosart: My understanding of what Dr. Laurence just said is that if it is "in-fence" it is a federal responsibility, but if your measures prove ineffective and it gets outside, then it is not your responsibility; am I correct?

Dr. Laurence: No; I am not a lawyer but there is a famous case which affects our policies there.

Senator Grosart: The Americans have some trouble in this too, but you are relying largely on the readily-given co-operation of the people in the provinces having responsibility in this area?

Dr. Laurence: Yes; indeed, I do not see how we could do otherwise.

The Chairman: If you were to establish your own services then it would be largely a case of duplication of services I suppose?

Dr. Laurence: Yes, indeed.

Senator Thompson: When you said in fence, do you mean by that within the site of a mine or actually on the site of a mine?

What about transportation of radioactive materials; do you set down a requirement across Canada?

Dr. Laurence: May I, Mr. Chairman, before answering that just make one further remark bearing on the previous question: it does seem to me that whether or not our officers were the ones who did the actual inspection and were directly instrumental in this control problem of relating it to what gets beyond the fence it would still call for that kind of collaboration with the provincial authorities, because they are the ones who are interested in what is happening on these waterways.

Senator Grosart: I raised the question because we have had over the years some rather horrendous examples of important problems falling between the two jurisdictions. A classic case is perhaps farm marketing boards where for years we could not have a farm marketing board because there was both divided and interlocking jurisdiction.

Senator Thompson: Could I come back on transportation which would be outside the fence: Do you have a common regulatory requirement across Canada with respect to transporting radioactive materials and the handling of such when the material is taken off a truck, or whatever it is taken off?

Dr. Laurence: I am going to ask Dr. Dewar to reply to this question, because he is closer to it. It is a rather complicated one because there are a number of different authorities involved.

Dr. Dewar: Perhaps I might say, Mr. Chairman, that there are federal regulatory authorities for transport by air, by rail and by sea, and these are very definitely federal.

In the case of transport by road, neither the federal nor provincial have taken any responsibility in any field except explosives, for which there is a federal act.

Senator Thompson: Does this come under explosives?

Dr. Dewar: No, this does not come under explosives.

Senator Thompson: In other words, we are completely open?

Dr. Dewar: It is open in all dangerous commodities. The Board has stepped in in the field of radioactive material; we have dealt with our licensees, the people who are using this material, and having imposed certain conditions on them which are as much as possible uniform with the standards that are being applied particularly in the rail transport, where they have very detailed regulations.

We have invoked these standards for road until such time as there is some road transportation authority set up, either federal or provincial.

Senator Thompson: How much of the material is transported by road today in Canada?

Dr. Dewar: Quite a good bit.

Senator Thompson: What about in the handling when they are taking it off the truck, I presume it comes in by truck, are there regulations that you impose?

Dr. Dewar: Yes, our regulations are imposed on the people who are normally handling it, our licensees type of thing, who are using it, but our controls have been exercised mainly in the proper packaging and proper labelling.

In this I might say we have been guided by proposed international regulations which were drawn up by the International Atomic Energy Agency. An officer of our Board was the Canadian adviser on these and he has, on the basis of this, drawn up certain sort of draft regulations which are being recommended to the various transportation authorities in Canada.

Meanwhile we are holding the nettle on this and insisting on proper packaging, proper labelling and so on.

Senator Thompson: But as far as road precautions, do you feel this is something that should be acted on quickly?

Dr. Dewar: We firmly believe that action should be taken on not only radioactive materials, but all dangerous commodities. I mean the shipment of chlorine or the shipment of anything like that is home free; there are no regulations now.

Senator Thompson: If you feel a need for this what is your procedure to get action?

Dr. Dewar: We have reported this in our annual report, sir, I think for three or four years.

Senator Grosart: There is no better way to bury it.

Dr. Dewar: I am afraid so.

Senator Grosart: On this question you spoke of imposing regulations on your licensees; I think what we are all trying to get at is whether your Board promulgate safeguard regulations in this field that are applicable to everybody anywhere in Canada and, if so, what authority is there behind those regulations and what statutory penalties are there for infractions? Do we have any?

I was looking at where you speak in your brief at page 7 of trying to persuade people to be good:

> Applicants for reactor construction permits are persuaded to carry out research and investigation that will give adequate support to the claims they make for the safety embodied in their reactor designs.

Persuaded.

Dr. Laurence: The word persuaded was used because this is not the kind of action that you can bring about through regulations I think, but what it implies is that the applicant is trying to make a case, he is trying to persuade the Committee that this is a safe plant. The Committee says to him in effect, well, we want to be shown.

Now, that is an invitation to do an investigation and prove that their claims are all that they say they are.

Now, behind that there is the authority of the Board to grant or not to grant a licence.

Senator Grosart: Is there any statutory obligation to provide proper safeguards for this hazard for all Canadians?

Dr. Laurence: The regulations apply to all Canadians.

Senator Grosart: And they have the authority of the Act?

Dr. Laurence: The authority of the Act stands behind them and there are penalty provisions in here; they certainly are used and, in fact, we have had on rare occasions to bring people into court; I think we have always won our case.

Dr. Dewar: Well, I think the most recent one involved a penalty of a $3,000 fine.

Senator Grosart: For a breach of the Board's regulations?

Dr. Dewar: Yes.

Senator Thompson: Could I come back again to the Port Hope situation, for example, where when the Eldorado mines were present they admitted that they thought it was useful that this Toronto university professor should come out and he had suggested that they should be more diligent in their precautions. They pointed out that one of the things that they noticed was that their signs, whether they fell down or not, or what happened to them, were insufficient and it was suggested that I should bring the question to you.

What are the penalties attached for not sufficient precautions and signs, and so on?

Dr. Laurence: We usually bring pressure through the implied threat that licensing may be in future restricted. This seems to be the most effective way of dealing with situations of this kind.

The example that you cite was a reminder to us that safety does require constant vigilance and fences out in the back pasture may be neglected.

Senator Thompson: Following on that remark, constant vigilance: How many inspections are made, for example, by your people or people delegated by you to checking the proportion of radioactivity in water near plants? Is this a daily thing, six months, a year? Throughout all the uranium areas?

Dr. Laurence: There is a very extensive continuing survey being carried out by the appropriate departments, mainly the Department of Health in Ontario, in the Elliot Lake area and the federal departments.

Senator Thompson: Do we have other uranium mines in Canada as well as in the Elliot Lake area?

Dr. Laurence: Yes, there are the mines in Saskatchewan.

The Chairman: Beaverlodge.

Senator Thompson: Are the precautionary methods carried out by the province of Saskatchewan on a similar basis to those carried out by Ontario?

Dr. Laurence: The problem has not been the same out there; there has not been the same pollution problem that has existed around the concentration plants in the Elliot Lake area.

Senator Thompson: I am talking of the check that is made; you mentioned that it is a constant check. What I am getting at is if each province has the authority to look after the check, one province may feel that this is an expensive proposition to them and they will not be doing as concentrated an effort as in another province and therefore it would seem to me that you would have to set a standard saying that we want this checked every week, or every month, or whatever scientifically you feel that it has to be checked.

Is there such a standard made?

Dr. Laurence: This is not a thing which lends itself to the setting of standards. The degree of inspection that may be required and the frequency of inspection must be appropriate to the circumstances of the existing conditions; it must relate to the amount of material that is being stored, where it is being stored, what is the nature of the waterways in the area, what precautions are being taken, what use is made of the water.

All of these things come in; I do not think you could set up any set of rules which would give you general guidance. Each case has to be judged on its merits.

Senator Thompson: Of course this creates, I would think, a great deal of difficulty, if you do not have a set of rules in the sense of giving a sense of security to the public if there are definite rules.

I appreciate what you are saying, but on the other hand I would have thought that there are certain basic standards which you would require with respect to this.

Dr. Laurence: The basic standard that guides us is the recommendations of the International Commission on Radiological Protection, that international body to which I referred a while ago.

For example, they recommend that water which is used continually, day after day, for domestic purposes should not contain more than certain concentrations of certain radio isotopes. That is the basic standard that guides us.

Now, in setting that standard, as you can see, one takes into account the use that is made of the water. The level that we would wish to maintain in Elliot Lake water, which enters the water supply of the town of Elliot Lake, would need literally to meet that requirement, but some tiny pond out near a mine head where nobody goes except occasionally fishermen who therefore are not going to be using the water continually, but only perhaps occasionally at the most, it is possible there to tolerate a much higher level.

So a certain amount of judgment has to come into this if you are not going to impose unreasonable restrictions on mining operators.

Senator Kinnear: I am so interested in the whole of the idea that radioactivity is at the base of all our trouble and that we are hoping that we are safe from radiation. I think that that is what it is coming down to, that the average Canadian is so worried and you just answered my question several times and especially when you said in Saskatchewan in some pond they can have a lot of radiation and it will not make any difference because there is nobody there, only once in a while, but it is the once in a while that I might be there, or somebody else, that frightens me.

Senator Grosart: Or you might get a fish from there.

Senator Thompson: Or water might flow into another pond.

Senator Kinnear: That is the point; I am on a polluted lake, Lake Erie, and we find so much pollution that I am very worried when we do not announce publicly the great safety that you seem to think is built into your process of protecting the public.

So my question would be: What is the difference between Saskatchewan and Ontario, but you have answered that. My full concern is safety from radiation.

Dr. Laurence: Perhaps to be definite on the record, I had not been comparing Saskatchewan with Ontario; I was talking about the hazards in the Elliot Lake area, and comparing the water supply of the town of Elliot Lake with the possible concentration which you might have close to a mine head which is remote from a centre of civilization.

Now, in view of the concern which members of the Committee have been expressing regarding the radioactive hazard I think, Mr. Chairman, I should say a little more in this regard.

The recommendations of the International Commission on Radiological Protection regarding permissible concentration in water which is used for domestic purposes every day are the recommendations of very cautious people. There is no sharp margin between what you can call dangerous and what is not dangerous; it is a relative matter, just like the dangers which we encounter in everyday life and every kind of human activity. It is a question of what is reasonable to accept and what is unreasonable and unnecessary cautiousness.

Radioactivity is not an important source of pollution in Canadian waters today compared with the other sources of pollution in the rivers and lakes of this country; I consider it entirely negligible.

Senator Grosart: What is fearsome and terrible is that it happens.

Dr. Laurence: Yes; this is certainly true, but some of these other things which we have accepted, merely because we have become accustomed to accepting them before we realized the hazard, can be just as terrible.

Senator Grosart: But you do not get accustomed to radioactive hazards, or do you?

Dr. Laurence: Earlier we talked about familiarity breeding contempt and there is the danger that the user can get careless; this is the thing that our Board and agencies that help us try to watch out for.

Senator Grosart: Have we got a fall-out problem in Canada? That is fall-out from external explosions?

Dr. Laurence: The amount of radioactive material that has fallen out has gone up and down following the ups and downs and the frequency of these experiments.

It is correct, is it not, Dr. Dewar, that it has never exceeded the limits recommended by the International Commission?

Dr. Dewar: I think it has always been well below.

Senator Grosart: What is the NRC division of radiobiology doing? Are they in this field?

Dr. Laurence: They are studying the effects of radiation; I am not very familiar with just what they are doing.

Dr. Dewar: This is radiation on the individual.

Senator Grosart: Yes.

Dr. Dewar: The director was a former officer from Chalk River.

Dr. Laurence: Yes, Dr. Gordon Butler.

Senator Grosart: But surely they are not working independently of your Board, are they? Are they not in the same field?

Dr. Laurence: In the same field and any information which would have a bearing on these basic standards would certainly be of very great interest to us and we would know about it, but what their present program is, I do not know.

It must be realized that this is quite a new branch; it is starting out and just getting organized.

Senator Thompson: What about miners, for example, working in the uranium mine? Are these constantly being watched from the clinical point of view and are you aware of the findings that are taking place?

Dr. Laurence: The answer is yes.

Senator Thompson: Could I ask a question with respect to page 10. It says:

> An important and immediate need in the technical development for which budget provisions should be made next year is better instruments to assist the Board's safeguards inspectors in identifying fissionable materials and estimating their composition.

I have two questions: The Board's safeguards and inspectors, do you have a number of men who are inspectors?

Dr. Laurence: We have three officers who act as inspectors from the point of view of safeguards.

Senator Thompson: And really in this you are saying that you need better instruments in order to evaluate this; would this be something again coming back to your research that you could be putting into research or have you already done that?

Dr. Laurence: No, we have not. This has become much more important to us in the last year or so. The prospect of the non-proliferation treaty has been one of the factors that has increased the importance of safeguarding.

The safeguards inspector's task is quite a difficult one; he is called upon to assess the quantities of material, to account for the material that has been shipped and to assess these quantities to make sure that they are in agreement with what was shipped and to make sure that they are the same material. For this he needs instruments to help him and there is great room for improvement in the instruments which are available to him.

Senator Thompson: But coming back to research, you are considering putting research money into this?

Dr. Laurence: Yes; we do not have money this year to do it, but we would like to have money for that purpose, but I think it has to be specially allocated for that purpose in our budget.

I would not want to see it lumped in with our university grants, because I do not think the universities are the best people to put on the job of developing these instruments; there are people existing in other organizations which have a background of experience which I think would be more appropriate.

Senator Thompson: Are there other countries which have better instruments than we have? Does the United States have better instruments?

Dr. Laurence: No; any instrument which is developed in one place is available to people elsewhere.

Senator Thompson: Are they doing research on instruments?

Dr. Laurence: Yes they are.

Senator Thompson: Would this mean that you would not need to do research on them?

Dr. Laurence: This brings up the old question of duplication in research. I am not sure there is any such thing as duplication in research. Research, after all, is a kind of search and two searchers are better than one, but apart from that I think that through a co-operative program with the United States we could probably bring to bear on such a problem some of their resources and some of ours in a way which would be better than an independent effort.

This is something that I think we should look into, the possibility of a co-operative effort here.

Senator Thompson: How can three inspectors possibly cover this field?

Dr. Laurence: They have their difficulties.

Senator Thompson: How many would you want?

Dr. Laurence: One is always tempted to mention a certain number which would be ideal, but you cannot find and train suitable people as quickly as you would like to do it, so any estimate that I would make there is always tempered by the practical consideration of how rapidly we would be able to train them and use them.

I would like to see this increased now at the rate of something like 50 per cent a year from now.

Senator Grosart: What level of scientific capability have these people? Are they Ph.D.'s, your inspectors?

Dr. Laurence: They are generally engineers chosen because of their background of experience after graduation in the relevant technology; experience here counts for a great deal.

Senator Thompson: Do we have a breakdown of what you spend your two and a half million dollars on research on?

Dr. Laurence: It is in one of the appendices, yes.

Senator Thompson: There is nothing that you could re-allocate to this protection approach?

Dr. Laurence: Not this year, certainly not. I beg your pardon, I should correct that: there is a small margin of it that is not committed but I would have a certain hesitation in doing that because at the time that amount was budgeted it was the understanding of the Treasury Board that this was intended for support of research in the universities, for the training of graduate students, and all that is involved in supporting university research, so that I would not want to do it without consulting at least with the Treasury Board.

Senator Thompson: You have in this, for example, on page 7, section 16:

> Applicants for reactor construction permits are persuaded to carry out research and investigation that will give adequate support to the claims they make for the safety embodied in their reactor designs.

How many of them are doing research? All of them?

Dr. Laurence: Oh, yes.

Senator Thompson: And to what extent are they doing this?

Dr. Laurence: An important part of the research and development work which is done by Atomic Energy of Canada Limited in preparation and during the course of the design of their nuclear power stations is the result of questions of safety that we have raised. I don't know what the proportion would be, but it is considerable.

Senator Thompson: What part of that research is funded by the Board?

Dr. Laurence: None of it; they pay for it. That is part of their development costs in designing the plant.

The Chairman: Thank you very much, Dr. Laurence, Dr. Dewar and Monsieur Hamel.

This was a very useful afternoon I think.

Dr. Laurence: Thank you, Mr. Chairman; if there is any further information we can provide we will be glad to.

The committee adjourned.

APPENDIX 9

Brief to the

SPECIAL COMMITTEE ON SCIENCE POLICY

OF THE SENATE OF CANADA

Submitted by the

ATOMIC ENERGY CONTROL BOARD

INDEX

PART I

ORGANIZATION AND FUNCTIONS OF THE ATOMIC ENERGY CONTROL BOARD

1. The Atomic Energy Control Board is one of the three Federal Government agencies in Canada specifically concerned with atomic energy.* The Board is mainly a regulatory body. Its chief purpose is to control nuclear and radioactive materials and nuclear energy equipment in the interest of national security and of safety from radiation hazards. Although the Board is not itself engaged in research and development, it is one of the agencies through which the federal government supports research by grants to universities.

ORGANIZATION

2. The present members of the Board are:

G. C. Laurence, President and Chief Executive Officer;

H. Gaudefroy, former Dean, Ecole Polytechnique, Montreal, now Director-General Liaison and Evaluation, Canadian International Development Agency, Ottawa;

W. M. Gilchrist, President, Eldorado Nuclear Limited;

J. L. Gray, President, Atomic Energy of Canada Limited;

W. G. Schneider, President, National Research Council.

* Eldorado Nuclear Limited, a Crown company, is engaged in the mining, extraction and processing of uranium, and in the manufacture of nuclear fuels, and does some pertinent research and development.

Atomic Energy of Canada Limited is a Crown company engaged in research and development in the field of atomic energy and the design of nuclear reactors and power stations, and the preparation and sale of radioactive materials.

3. The Board's staff consists of 28, of whom 13 have professional qualifications, most of them being engineers. The extraordinarily rapid development of peaceful uses of atomic energy and of the application of radioactive materials has brought about a corresponding increase in the activities of the Board. These functions are described in the following section. The increasing demand for its services has been more rapid then foreseen with the result that in recent years the Board has been understaffed.

4. The Board's Financial Statement for the Fiscal Year 1967-68 will be found in Appendix I.

FUNCTIONS

Strategic Atomic Energy Materials

5. In the interest of national security, all dealings (as defined in the Atomic Energy Control Regulations) in strategic atomic energy materials, such as uranium, thorium, plutonium and heavy water, are controlled under a permit system. Exports and imports of these materials are controlled in cooperation with the Department of Trade and Commerce and the Department of National Revenue. During the last fiscal year the Board issued 169 permits for export and 50 for import. In the same period, the Board issued 70 permits for uranium exploration and 3 for uranium mining.

Radioisotopes

6. Dealings in radioisotopes are controlled by the Board through a comprehensive licensing system. Licences are issued only after the Board and its advisers are satisfied that the proposed use can be made without undue danger of injury or damage. If the use is for a medical purpose the application is reviewed by the Department of National Health and Welfare's Committee on Clinical Uses of Radioisotopes and is checked to ensure that the material requested complies with the requirements of the Canadian Food and Drug Regulations. Periodic inspections are made, usually by officers of the Department of National Health and Welfare, on behalf of the Board, to ensure that the health and safety provisions of the regulations and any licensing conditions are being followed. During the last fiscal year 16,152 shipments of radioactive isotopes were licensed.

Reactor Safety

7. Permission from the Board is required for the construction and operation of nuclear reactors in Canada outside of federal government establishments. In the granting of such permits the Board has the advice of its Reactor Safety Advisory Committee, which was established in 1956. Five Scientific Advisers of the Board's staff follow the design, construction and operation of these reactors from the point of view of safety, act as inspectors, and assist the Reactor Safety Advisory Committee generally. The Reactor Operators Examination Committee examines the qualifications of proposed operators of nuclear reactors on behalf of the Board.

Accelerator Safety

8. The Accelerator Safety Advisory Committee, established in 1962, enquires into the hazards associated with the operation of the atomic energy research equipment in universities that have been financed with the assistance of grants through the Atomic Energy Control Board, and, on request, the radiation hazards in operating similar equipment financed from other sources. The committee is assisted by one of the Board's Scientific Advisers.

Special Fissionable Substances

9. The fissionable substances Uranium-235, Uranium-233, Plutonium and substances containing them in unnaturally high concentration, are capable of producing a dangerous uncontrolled chain reaction under conditions which might occur accidentally outside nuclear reactors unless precautions are taken to avoid them. In 1962 the Board instituted a licensing control system which, through its provisions, allows the Board to satisfy itself of the adequacy of the safety and protective measures used in handling these materials. 26 such licences were issued during the last fiscal year. The review of the protective measures and the inspection is an important part of the duties of one of the Board's Scientific Advisers.

Transportation of Radioactive Materials

10. The Board provides technical advice to the regulatory authorities for rail, sea and air transportation in connection with the packaging and shipping of radioactive materials. The Board itself has served as the regulatory authority for the transport of radioactive materials by road, pending the promulgation of dan-

gerous commodities transport regulations that would be applicable. It also advises packaging designers, shippers and carriers regarding the regulatory requirements for the transportation of radioactive materials. It endeavours to promote uniformity in the regulations applicable internationally and domestically.

International Activities

11. The Board supplies scientific and engineering advice on the various aspects of atomic energy to the Department of External Affairs. During the last year negotiations leading toward safeguards agreements were carried out with Brazil, Argentina and France. Discussions were held with the USA on the general safeguards and reporting procedures to be applied to uranium of Canadian origin which is to be toll enriched in the USA and re-exported to a third country.

12. To contribute to the development of effective safeguards procedures, Board officers took part in the deliberations of a working group established by the International Atomic Energy Agency to formulate special procedures for the extension of the Agency's safeguards system to nuclear fuel conversion and fabrication plants. Officers of the Board took part in other international conferences and metthings dealing with the various aspects of atomic energy.

13. Officers of the Board have performed safeguard inspections in the Federal Republic of Germany, Switzerland, Japan and India to confirm that nuclear materials supplied by Canada were being used for peaceful purposes only. When the Non-Proliferation Treaty becomes effective the scale of safeguarding inspection throughout the world will greatly increase and Canadian inspectors will be involved. The Board's officers will also be called upon to provide the liaison in the application of international safeguards in Canada to our nuclear energy activities.

Grants in Aid of Research in the Universities

14. In addition to its activities in formulating with the approval of the Governor-in-Council, and administering, regulations in the field of atomic energy, the Board is authorized to "establish, through the National Research Council or otherwise, scholarships and grants in aid for research and investigations with respect to atomic energy, or for the education or training of persons to qualify them to engage in such research and investigations." Its grants are spent mainly in defraying the cost of acquiring atomic energy research equipment, in maintaining and operating such equipment, and in defraying the other expenses involved in its use. Further information on the Atomic Energy Control Board Research Grants is given in Appendices II and III.

PART II

DEPENDENCE OF ATOMIC ENERGY CONTROL BOARD ON SCIENTIFIC RESEARCH AND ADVICE FROM EXTERNAL SOURCES

15. It has been the policy of the Atomic Energy Control Board to avoid establishing research facilities of its own. It receives considerable assistance in scientific advice from research personnel in other government organizations, including Atomic Energy of Canada Limited, the Department of National Health and Welfare, the National Research Council, Eldorado Nuclear Limited, the Geological Survey of Canada, and the Mineral Resources Division of the Department of Energy, Mines and Resources. Sometimes research is undertaken to provide the information. Even when new research is not required by it, the advice needed calls for the kind of detailed scientific knowledge that research scientists are most competent to provide.

16. Scientific advice is sought on many questions that arise in assessing the safety of proposed nuclear reactors for licensing purposes, and in the safe handling of fissionable materials and radioactive substances. The help of scientists in the National Research Council and the Department of National Health and Welfare is particularly valuable to us in this regard. In the course of the reactor safety reviews, questions arise that can only be resolved by experiment. Applicants for reactor construction permits are persuaded to carry out research and investigation that will give adequate support to the claims they make for the safety embodied in their reactor designs.

17. Important technical assistance is provided by the Radiation Protection Division of the Department of National Health and Welfare, some of whose officers act as inspectors on behalf of the Board to verify that radioactive materials licensed by the Board for use in

hospitals, industry, universities and other places are handled in compliance with the Board's regulations with respect to safety and other requirements.

18. Advice is often sought also in regard to scientific problems that could arise in connection with the inspection of atomic energy facilities abroad, to confirm that nuclear materials exported from Canada are used for peaceful purposes only in compliance with the treaty obligations of the receiving nations.

19. Members of the staff of some of the federal organizations mentioned above, as well as provincial civil servants and scientists from the universities, are members of the Board's Reactor Safety Advisory Committee and Accelerator Safety Advisory Committee, and their contribution in this regard is very valuable to the Board.

20. The Board, owing to its concern for protection of the public from the hazards of radiation exposure, is particularly aware of the need for the extension of scientific knowledge in regard to some of the biological effects of radiation, the uptake of radioactive contaminants in rivers and lakes by plants and animals, the retention and localization in the human body of particular radioisotopes that have been inhaled or ingested, and other relevant questions. There is considerable research in these subjects throughout the world, and the results are eagerly followed.

21. The greatest difficulty in assessing safety of a nuclear power station is in estimating how much radioactive material might escape from damaged nuclear fuel in the event of an accidental equipment failure, and escape from the equipment, escape from the building, and be carried as dust in the air or as solution in rivers so that it would endanger health at a distance from the plant. Where there is uncertainty it is the practice to assume the worst, which leads to costly protective measures. Research investigations intended to reduce these uncertainties are very important because they would provide the justification for reduction is safety precautions. Examples of studies of this kind are the survey of the movements of water in Lake Huron close to the Douglas Point Nuclear Power Station conducted by the Great Lakes Institute under contract to Atomic Energy of Canada Limited, and experiments at the Idaho National Laboratory as part of the collaboration program of Atomic Energy of Canada Limited and the United States Atomic Energy Commission to determine how much radioactive iodine accidentally released from damaged fuel in certain circumstances could escape from the reactor building.

22. Atomic energy technology is developing rapidly and subject to continuing change which is followed closely by the Board's staff. Such change leads to important new problems for the Board, particularly in regard to its inspection and licensing activities. An important and immediate need in technical development for which Budget provisions should be made next year is better instruments to assist the Board's safeguards inspectors in identifying fissionable materials and estimating their composition.

PART III

ENCOURAGEMENT OF APPLIED RESEARCH AND FUNDAMENTAL RESEARCH IN ATOMIC ENERGY IN CANADA

23. The Atomic Energy Control Board, through its regulatory and advisory activities, has associations with all aspects of the development and use of atomic energy in Canada. Some of its impressions regarding the problems of encouraging research and development in atomic energy in Canada, reflected in the following comments, may, therefore, be of some interest to the Senate Committee on Science Policy.

Applied Research

24. It has been the policy of the federal government, particularly through the efforts of the Atomic Energy of Canada Limited and Eldorado Nuclear Limited to encourage as far as possible the participation of private corporations in the building up of a nuclear industry in Canada.

25. Experience in atomic energy development in Canada has brought out very clearly the difficulties in fostering nuclear research in small industrial corporations. The disadvantage of small company size is not limited to the nuclear industry. It is a matter of concern expressed in the recent study of the Committee for Science Policy of the Organization for Economic Cooperation and Development carried out in its member countries. They recognize that corporations of moderate size are often able, through their own efforts in research and development, to produce a successful product when the unit costs are relatively small and the quantities are large.

However, where the unit costs of the finished product is high, as in the so-called heavy industries, the large corporation has a great advantage because it can invest the larger sums in research and development that are necessary before profits are realized, and it can accept the capital risks involved. Not surprisingly, it is chiefly in these areas that Canadian industry is least well equipped for research and development.

26. A nuclear power station is a product of very high unit cost. The number that can be marketed is relatively small. Canada very wisely concentrated on the development of only one type, and the choice of the natural uranium heavy water concept is proving to be sound. The United States has devoted most development work to two other types and already about a dozen have been built and put into operation and nearly forty are under construction. For the nuclear energy program in Canada, which is so much smaller, the research and development costs are, consequently, a greater relative burden, and longer time is needed for development.

27. A major difficulty in an industry dealing with very few and very large contracts is the fluctuation in the workload which affects even research and development. It is difficult to maintain an efficient research organization intact in the intervals between contracts. Although AECL has made great effort to assist private industry in building up research and development competence by contracts, and by encouraging some of the best of its own employees to find employment in the companies concerned, private industry in Canada has hesitated to establish research organizations suitable for nuclear energy problems. Two of the companies which did so a few years ago have practically abandoned their efforts to continue research in the field. It appears that the financial resources of government are needed to provide for very large investment in research and development where there are such very large fluctuations and irregularities in financial returns.

28. Of course, "innovation" involves more than research. The process of innovation may progress through many stages before the product is ready for marketing; the idea, an outline conceptual design, testing to find suitable materials, trials with models or mockups, redesign in the light of that experience, construction of a prototype, and elimination of faults by cut and try changes. Even when little or no research is involved, progress through these stages often requires considerable knowledge of the background science and technology. Such knowledge is most likely to be found in corporations that have an imaginative research staff that is able to maintain close contact with those engaged in the other aspects of innovation, and with management.

29. Effective use of scientific knowledge and research talent in industry requires considerable understanding by senior management of what research is, how it fits into the innovation process, and how scientists and research engineers think and work. This is one of the difficulties in encouraging research and development capability in companies where there has been little use of research in the past. Confidence in research and development comes from experiencing its successes.

30. It is unlikely that any radical change in policy or practice would quickly overcome these difficulties. There has been great progress since the war; further progress will continue to depend on government spending, on our efforts to keep abreast in scientific programs, and not least on the efforts of Canadian industry to stimulate and to exploit innovation.

The Role of Fundamental Research

31. In nuclear energy development, the contribution of scientists whose backgrounds were in basic science, working in collaboration with applied scientists and engineers, has been indispensible. In other industries as well, it is noticeable that large corporations that are particularly successful in innovation are also highly competent in research of a fairly fundamental nature. The laboratories of the Bell Telephone Company and the General Electric Company have provided many examples of achievement in basic science. The Ford Motor Company also is becoming very active in fundamental research. Fundamental scientists were the first to see the possibilities of application that led to atomic energy, high speed computing devices, transistors, etc. The nations that are industrially highly developed are just those nations that have reason to be proud of their achievements in fundamental science.

32. Concern has been expressed that our universities, by their emphasis on basic research, are neglecting training specifically for applied research. It is true that many research scientists would benefit from more

training in some engineering subjects. However, knowledge and skill in the application of science can develop on the job, but the foundation of basic science that is needed is not so easily acquired after leaving the academic environment. Students with the kind of curiosity that is required for research are usually attracted first by fundamental science. Later with greater experience and new responsibilities, the interest of many of them turns to application. They would not be scientists at all, fundamental or applied, if they had not been first attracted by fundamental science. This is one of the important reasons for the emphasis on fundamental science in our universities.

33. The urge to do research in the physical sciences and engineering stems from a great curiosity about materials and processes. The good applied research specialist, through his work, often becomes aware of gaps in scientific knowledge that excite his curiosity, even though the commercial application is not obvious. If he is discouraged by short-sighted cost-benefit accounting practices from occasional digression away from immediate application, his keenness will be destroyed or he will be frustrated to the point of seeking employment elsewhere. Applied research inspires fundamental research, just as fundamental research arouses interest in application. The two are complementary and thrive better together. This is true in government laboratories as in industrial laboratories.

34. The Atomic Energy Control Board is wholly in sympathy with the current efforts to build up competence in applied research in Canadian industry. In the present emphasis on applied research, however, there has been some tendency to regard basic research as a less worthy competitor—not as an essential partner. The preceding paragraphs are prompted by concern that support of fundamental research may suffer unduly in consequence.

APPENDIX I

ATOMIC ENERGY CONTROL BOARD
FINANCIAL STATEMENT FOR THE YEAR 1967-1968

RECEIPTS

Parliamentary Appropriations—		
Vote 1 (Administration Expenses A.E.C.B.)	$ 301,717	
Vote 5 (Research and Investigations with Respect to Atomic Energy)	$2,500,000	
		$2,801,717

EXPENDITURES

Administration Expenses A.E.C.B.—		
Salaries and Wages	$ 255,071	
Professional and Special Services	340	
Travelling Expenses	25,224	
Postage	366	
Telephone and Telegrams	4,976	
Publication of Annual Report and other material ..	1,108	
Office Stationery, Supplies and Equipment	10,117	
Expenses of Board Members		
Sundries	4,515	
		$ 301,717
Grants-in-Aid (Research and Investigations with Respect to Atomic Energy)—		
Capital and Annual Research Grants		$2,500,000
Total Expenditures		$2,801,717

APPENDIX II

ATOMIC ENERGY CONTROL BOARD RESEARCH GRANTS TO UNIVERSITIES

1. The Board's grants in aid of research within the last five years were distributed to Canadian universities as indicated in the following table:

AECB RESEARCH GRANTS TO UNIVERSITIES
Expressed in Thousands of Dollars
(NRC Grants for Nuclear Particle Accelerators are shown in Parentheses)

	1962–63	1963–64	1964–65	1965–66	1966–67	1967–68
U. of Alta	73.0 (226.0)	73.0 (226.0)	93.0 —	105.0 —	160.0 —	254.0 —
U.B.C.	120.0	150.0	235.0	270.0	320.0	321.0
Laval U.	34.0 —	34.0 (275.0)	79.0 (65.5)	190.0 —	270.0 —	362.0 —
U. of Manitoba	95.0	120.0	140.0	180.0	250.0	298.0
McGill U.	125.0	140.0	155.0	170.0	200.0	234.0
McMaster U.	140.0 —	170.0 —	180.0 —	185.0 —	200.0 (540.0)	226.0 (580.0)
U. of Montreal	33.0 —	33.0 —	33.0 (75.0)	25.2 (316.0)	— (414.8)	— (635.0)
Queens U.	55.0	55.0	55.0	130.8	69.0	120.0
U. of Sask.	95.0 (250.0)	125.0 (250.0)	280.0 —	345.0 —	431.0 —	481.0 —
Ottawa and Carleton U.	— —	— —	— (250.0)	— (25.0)	— (39.9)	81.0 —
Toronto U.	— —	— —	— (550.0)	— (125.0)	— (200.0)	23.0 (320.0)
Triumf	— —	— —	— —	— —	100.0 (20.6)	100.0 —
AECB Total	770.0	900.0	1,200.0	1,600.0	2,000.0	2,500.0
NRC Total	(475.0)	(750.0)	(940.5)	(466.0)	(1,202.7)	(1,535.0)

2. The National Research Council also makes grants for a similar purpose. These are included in the tabulation in parentheses in order to provide a more complete picture of the distribution of federal government support of atomic energy research involving large research installations in the universities. It does not include a number of comparatively small grants to some individual scientists, and NRC scholarships to graduate students who make some use of the equipment financed by these grants. The two agencies consult and collaborate closely in making these awards and the fact that a particular university is supported by one agency or the other is merely a matter of administrative convenience. It is the total to a particular university from both agencies that is significant.

3. All of the funds available to this agency for support of scientific activities was actually expended during each of the fiscal years 1962-63 to 1967-68. The percentage of the total

funds requested that was actually granted was as follows:

1962-63	77.0%
1963-64	83.6%
1964-65	78.4%
1965-66	82.7%
1966-67	83.4%
1967-68	86.3%

4. A large part of this expenditure on nuclear energy research in the universities is for the construction and use of "particle accelerators" and the associated equipment. Particle accelerators are large electrical devices which accelerate electrically charged parts of atoms, called "ions" or "particles", to very high energies. These particles, travelling at very high speed, can be thought of as probes with which the scientists investigate the structure of atoms. Most of our understanding of nuclear energy phenomena has been gained through their use.

5. The higher the energy of the particles is the more effective they are in revealing fine details in the atom. This has led to the proposal for the so-called TRIUMF particle accelerator which is much more powerful than any at present existing in Canada. It is expected to cost $19,000,000 to build, and thereafter $4,000,000 per annum to operate it and the associated research laboratories. Although located on the campus of the University of British Columbia, it is intended to serve in addition the Universities of Victoria, Simon Fraser and Alberta.

6. TRIUMF is not designed to compete with the much larger and more costly particle accelerators in other countries that are used in the search for not yet discovered kinds of elementary particles and the study of their properties. TRIUMF is of intermediate size and is intended chiefly for a different kind of research, that is, research in important areas of nuclear physics that have yet scarcely been explored. It would give Canadian scientists the advantage of opportunities of research in this field that would be almost unique in the world.

Approval of Applications for Grants

7. Application to the Board for a grant in aid of research is made by the scientist who assumes responsibility for its conduct. He is usually the head of a university department or the leader of a small group of scientists. The application is accompanied by considerable information regarding the design and expected performance of any new apparatus as well as the kind of research problems to which it will be applied. Information also is provided regarding the scientific careers of the applicant and his associates. Information is provided on the intended use of the funds, detailed under such headings as maintenance, ancillary equipment for special experiments, general laboratory supplies and replacements, salaries of technical staff and operators, power, etc. A report is required on the research conducted during the previous year and on the future program.

8. These applications are reviewed by a small committee* which includes scientists of established reputation in nuclear energy research, and, for liaison reasons, the President of the AECB. This committee, called the AECB/NRC Visiting Committee, reports to both the AECB and the National Research Council. Thus, by bringing the applications to the two organizations under review by the same committee, a common standard is established and duplication is avoided. Each recipient is visited about once a year by at least one of the committee and from time to time by the committee as a whole.

9. Obviously the award of the grant and its amount depends very much on the judgment of the committee in its assessment of the abilities, judged by past performance, of the applicants and of the scientific investigations they propose to undertake. There appears to be no other practicable way of assessing the promise of fundamental research than the judgment of specialists in the field, but it is remarkable in practice how closely the judgments made quite independently by good scientists agree in such appraisals.

10. In recent years, the Board has endeavoured to avoid encouraging the establishment of new centres of atomic energy research in Canadian universities, believing that funds available for nuclear energy research are better spent by building up the

*Members of the Committee are:
- Dr. L. G. Elliott, Director of Research, Atomic Energy of Canada Limited—Chairman;
- Dr. G. Griffiths, Professor of Physics, University of British Columbia;
- Dr. E. P. Hincks, Professor of Physics, Carleton University;
- (Alternate: Dr. J. T. Sample, Professor of Physics, University of Alberta);
- Dr. G. C. Laurence, President, Atomic Energy Control Board;
- (Alternate: Mr. P. E. Hamel, Assistant Scientific Adviser—Accelerators, AECB).

strength of existing centres, and that less benefit will result if they are spread too thinly. It is not necessary or possible for all universities to be strong in nuclear science; some universities should be encouraged to excel in other branches of physical science.

APPENDIX III

BRIEF COMMENTS ON RESEARCH SUPPORTED BY THE ATOMIC ENERGY CONTROL BOARD

L. G. Elliott*

1. The following eleven universities have major installations in nuclear science and receive grants in aid of research from the Atomic Energy Control Board:

McGill University, Montreal,
The Foster Radiation Laboratory

2. The main research facility at this laboratory is a 100 MeV proton synchro-cyclotron. The machine began operation in 1950 and is still the highest energy proton accelerator in Canada. Centered about this accelerator is a well-conducted and active program in nuclear structure and cross-section studies. Of particular note, internationally, was the discovery and competent study in this laboratory of a series of nuclear species which emit delayed protons. About 7 professors, 3 post-doctorate fellows, and 19 graduate students are using this facility at the present time.

University of British Columbia,
Vancouver—Physics Department

3. Low energy nuclear physics research is carried out at this University using a 2.5 MeV electrostatic generator which came into full operation in 1952. This machine provides beams of protons, deuterons, He-3, and He-4 ions, and a detailed and worthwhile study of nuclear reaction mechanisms is being carried out. About 7 professors, 3 post-doctorate fellows and associated graduate students are presently using this facility. It is anticipated that this machine will phase out of use during the next five years as the TRIUMF facility (described below) comes into operation.

4. Several small scale experiments in plasma physics research are being supported in this University and a significant research contribution is being made by a team of about 5 professors, 2 post-doctorate fellows and 20 graduate students.

McMaster University, Hamilton

5. The operation of a nuclear research reactor is supported at this University. This reactor began regular operation in 1960 and is the only reactor on a Canadian university campus at the present time. Strong research programs, also supported by the NRC, are directed by some 25 university staff members in the fields of Biochemistry, Biology, Chemistry, Chemical Engineering, Geology, Metallurgy, Nuclear Engineering, Nuclear Medicine and Physics.

University of Alberta, Edmonton,
Nuclear Research Center

6. Nuclear physics research was started at this University using a 2 MeV electrostatic accelerator and was expanded in 1964 when a 5.5 MeV electrostatic accelerator was acquired. The research group, consisting of some 6 professors, several post-doctorate fellows, and associated students, have a productive program on nuclear structure and reaction studies and have demonstrated special competence in neutron measurement techniques and on-line computer data processing.

Université Laval, Québec—
Laboratoire du Van de Graaff

7. A 5.5 MeV electrostatic accelerator was commissioned at this University in 1964. Significant programs of study of nuclear reactions, motions of charged particles in crystalline solids, and the atomic spectra from multiply ionized atoms have been initiated and are growing. About 4 professors, several visitors, and 12 graduate students are involved in this work at present.

University of Manitoba, Winnipeg,
Cyclotron Laboratory

8. A spiral ridge cyclotron with an intense beam of 50 MeV protons was constructed in this laboratory and in 1964-65 came into oper-

* Dr. Elliott is Chairman of the AECB/NRC Visiting Committee (see page 20).

ation. During the past three years an effective research team of about 6 professors, several post-doctorate fellows, and associated graduate students has been assembled and several advanced techniques in nuclear structure studies are now being exploited.

University of Saskatchewan, Saskatoon, Physics Department

9. In 1950 a 25 MeV electron betatron was acquired by this University and notable pioneering work in photonuclear studies was carried out over the next decade by a team of about 3 professors and associated students. In 1965 a 140 MeV linear electron accelerator was commissioned and an active team of about 3 professors, several post-doctorate fellows, and associated students have now developed a significant program in studies of nuclear structure and the interactions of high energy electrons with nuclei.

10. Several modest experiments in plasma physics research are being supported at this University and a worthwhile contribution is being made by a team of 3 professors, 3 post-doctorate fellows, and associated graduate students.

Queen's University, Kingston, Physics Department

11. A 70 MeV electron synchrotron was used for about fifteen years in a modest nuclear physics research program at this University. This facility has now been augmented by a 3 MeV positive ion accelerator which became operational in 1966. A team of about 5 professors and associated graduate students are now developing a program of nuclear structure studies with this accelerator and with larger accelerators at Chalk River Nuclear Laboratories and the University of Toronto.

University of Ottawa and Carleton University—Dynamitron Facility

12. An intense 3 MeV positive ion accelerator was commissioned at the University of Ottawa in 1967 and is intended for joint use by the Physics Departments of the University of Ottawa and Carleton University. About 5 professors and associated students intend to use this facility in nuclear structure and reaction studies.

University of Alberta, University of British Columbia, Simon Fraser University and Victoria University

13. A new project known as TRIUMF, with the joint participation of the above four universities, has recently been initiated. A strong team of scientists has now been formed and has commenced the design and development of an intense 500 MeV proton spiral ridge cyclotron for use as an effective research tool in the developing field of intermediate energy nuclear physics.